NuDiVe

Nuclear Disarmament Verification

Documentation of the NuDiVe Exercise

September 2019

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Preface

The NuDiVe (»Nuclear Disarmament Verification«) exercise held in September 2019 was the first comprehensive nuclear dismantlement exercise within the framework of the IPNDV (»International Partnership for Nuclear Disarmament Verification«). It was initiated by the Federal Republic of Germany and the French Republic.

Experts from all over the world took on the roles of inspectors and inspected state to simulate the verified dismantlement of a nuclear warhead, with a particular focus on the inspection procedures and their interactions.

The »NuDiVe Documentation« is not only a summary of the exercise but an in depth documentation, providing details, sources and many of the in-game documents prepared for NuDiVe. A reader interested in a concise overview will find it it the introductory chapter, whereas the following chapters provide exhaustive information on all technical and organisational aspects.

This document will *not* provide an exhaustive introduction to the background and general principles of nuclear disarmament and dismantlement exercises. For such an overview, please refer to the exhaustive set of publications offered by IPNDV.

All of the NuDiVe documents are sorted and provided in Appendices. Throughout the document, they will be put into context and explanation will be given to understand their function and the rationale behind their design.

Also attached is the report by the NuDiVe evaluation team, which will be cited and referred to throughout this document.

NuDiVe has been a challenging undertaking, requiring thousands of working hours from organisers and participants to reach its successful conclusion. The organisers hope that by aiming for transparency and publishing the methods and findings in the most complete manner, the impact of their efforts will be maximised by providing a fruitful basis for IPNDV and the scientific community to develop and test verification methods and technologies fit for inspection regimes truly enabling verified, multilateral nuclear disarmament.

1. Overview of the exercise

The NuDiVe exercise was aimed at demonstrating a complete and practical framework for the multilateral inspection of a nuclear warhead dismantlement process. It was created to integrate in the broader framework for nuclear disarmament verification that is being developed within the IPNDV (see Figure 1.2.1).

In the exercise, participants assumed the roles of personnel from a fictional nuclear weapon state (the »host«) dismantling one of its nuclear warheads, and a team of inspectors verifying that the dismantlement took place according to the standards of a fictional treaty.

The challenge in nuclear dismantlement verification is always to strike a balance between the inspectors' goal of collecting sufficient information to rule out any treaty violation, particularly the diversion of fissile material, and the inspected state's requirement to ensure the security and integrity of its confidential information and proliferation sensitive data. In NuDiVe, these issues were addressed by developing a thorough inspection regime based on many of the concepts pioneered in IPNDV and the wider nuclear disarmament research community.

1.1. Structure of the exercise

The exercise was conducted at the radiation protection facility of the Forschungszentrum Jülich in Germany, which provided realistic surroundings. The teams were drafted from IPNDV experts and consisted of 8 participants each.

The host team was tasked with conducting the simulated dismantlement operation. They also had to carry out the required inspection procedures at the behest of the inspectors, while controlling the inspectors access and movement in order to prevent access to any classified information.

The inspectors were tasked with observing the dismantlement and inspections and help enact the inspection regime so they could collect sufficient evidence that the dismantlement was successfully conducted without the possibility of diverting fissile material from the chain-of-custody.

For security reasons, all inspection activities were conducted by the host personnel under observation of the inspectors in order to keep them from gathering sensitive data. Within the dismantlement facility, the inspectors were closely guarded at all times and required to wear protective suits preventing the accidental, or intentional, collection of radioactive particles.

Both teams were operating within the scenario for the entirety of the exercise, and private contact was restricted in order to obtain a professional and adversarial setting that could be realistically expected within a military installation.

The whole process was accompanied by an independent team of experienced evaluators tasked with observing and analysing the exercise and interviewing participants to prepare a thorough evaluation of the exercise and proceedings. Their report is part of

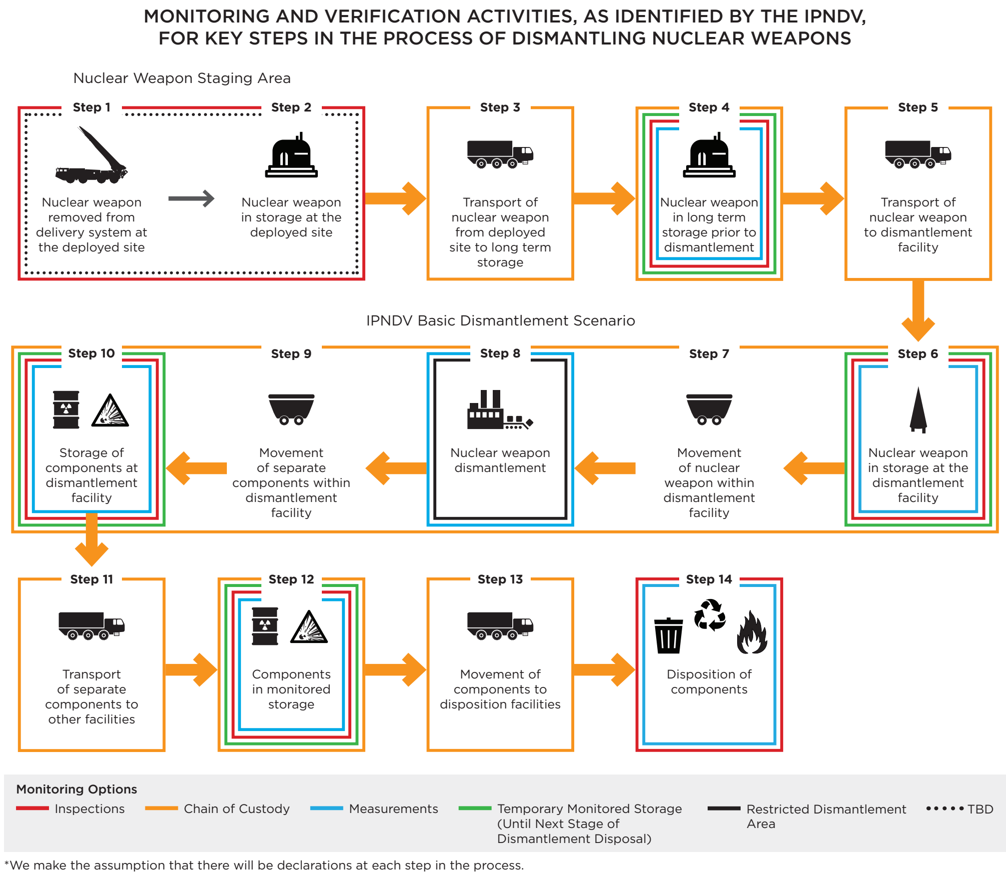


Figure 1.2.1.: The 14 step process for dismantling a nuclear warhead according to the IPNDV. [International Partnership for Nuclear Disarmament Verification: *Phase I Summary Report: Creating the Verification Building Blocks for Future Nuclear Disarmament*, 2018]

this documentation.

1.2. Inspection setting and logic

In the exercise scenario, a fictional state called »Urania« was dismantling part of its nuclear arsenal as mandated by the fictional »NuDiVe Treaty«. Following the systematic approach outlined in Figure 1.2.1, upon the declaration of the arsenal each warhead was to be removed from its deployment site and enter the chain-of-custody, a continuous documentation of the state and whereabouts of the warhead and its components until their final disposition.

This chain-of-custody was mostly realized using technologies for sealing and tagging the warheads in dedicated containers, which provide a high level of security and traceability. The critical point was the dismantlement of the warhead in Step 8, during which the the sealed container had to be opened to handle the warhead, a process which could be observed by inspectors because of its sensitive nature. Still, the inspectors had be able to confirm that during the handling of the warhead, no radioactive material could have been diverted from the chain of custody.

The NuDiVe exercise focused on simulating an inspection of Step 8. This was done by following the inspection procedure which was developed for this exercise and encompassed many state-of-the-art methods and technologies for disarmament verification.

1.3. Tools and technologies

The NuDiVe exercise was using working technologies operated by the participants whenever possible. They were selected with a focus on robust, proven technologies as opposed to novel or experimental ones. This was done in order to demonstrate the interaction and interoperability of verification methods to create a multi-layered inspection regime following the principle of redundant inspection measures: when one technology failed to provide conclusive results, another technology applied simultaneously would fill the gap.

Radiation detection with hand-held gamma and neutron detectors was used to screen the dismantlement area before and after the dismantlement process to ensure no fissile material was hidden and diverted from the chain-of-custody. During the whole inspection, portal radiation monitors were guarding the entry of the dismantlement room to alert the inspectors in case of unauthorised movement of fissile material. For increased realism, the fissile material in the exercise was simulated using a surrogate radiation source emitting gamma and neutron radiation comparable to a small quantity of nuclear weapons usable material.

A CCTV surveillance system was operating throughout the exercise. It covered all critical areas like the entry to the Dismantlement Room and the storage room for the equipment. The system was used extensively as a secondary verification measure in NuDiVe. The footage was not transmitted live to the inspectors, but handed over by the host when requested. A system of two separate recording computers was implemented to guarantee the integrity of the footage.

Much of the authentication and access control was handled using seals, which were also employed to close potential diversion pathways. In order to streamline the process, only adhesive seals were used in combination with a reflective particle lacquer applied in situ to give each seal a unique, non-replicable signature. The seals were verified by taking and comparing photographs with a digital camera.

These technologies are not the only ones applicable in the proposed inspection regime, but serve as a stand in for a range of related methods. It is expected that the regime will evolve and replace some technologies with novel, more suitable or specialised methods. The authors anticipate that the detailed instructions and feedback collected in this documentation can aid the development and evaluation of such methods.

1.4. Results and evaluation

The exercise was concluded successfully and participants were satisfied that the objectives of the inspection were accomplished. The dismantlement procedure was conducted within the allotted time. The chain-of-custody remained intact and there was no opportunity for the diversion of fissile material. There also was no opportunity for the inspectors to obtain sensitive or confidential information.

The evaluation agreed that the exercise was successful and demonstrated a functioning inspection regime applicable within the IPNDV disarmament framework, using working technologies in a realistic setting. The comprehensive evaluation report also includes many findings and suggestions to further improve the inspection procedures and technologies, many of which are expanded upon in this documentation.

2. Scenario

2.1. Urania

The »Republic of Urania« is the fictional state around which the NuDiVe exercise is centred. It was designed to represent a nuclear weapon state in a realistic disarmament scenario without directly mirroring any actual country. As NuDiVe is an exercise to support IPNDV, Urania does bear similarities to the participating states. Most importantly, Urania is party to the Nuclear Non-Proliferation Treaty. A map is shown in Figure 2.1.1 and the detailed background document can be found in Appendix A.1 on page 66.

Urania's nuclear arsenal encompasses 650 active warheads deployed in a classic nuclear triad of ground-based, sea-based and air-based delivery systems. This relatively large number was chosen because it was deemed realistic that disarmament efforts might focus on larger arsenals first. Detailed information on the arsenal can be found in Appendix A.2 on page 71. This elaborate and detailed approach was chosen for two reasons. First, it was to provide colour and depth to the scenario by providing context for the inspectors without offering to much information about potentially classified aspects. Second, it could serve as a basis for discussion in IPNDV on how to handle different parts of a nuclear arsenal when the NuDiVe scenario is extended in later exercises or deliberations.

The capabilities and dimensions of the fictional »GKP-3 Vreddesbringer« delivery vehicle can be found in Appendix A.3 on page 74. It was assumed that Urania would declassify and release some information on the treaty accountable items to build trust and facilitate baseline inspections. Accordingly, it was declared that the warhead in question is designated »SH-2«, has a nominal yield of 150 kt and is based on weapons-grade plutonium. This should be representative of a flexible multi-purpose warhead within a modern nuclear arsenal.

Several nuclear weapons sites have been declared in Urania, including the Nuclear Weapons Campus at Jülich[1] where the dismantlement would take place.

2.2. Treaty and inspection regime

The NuDiVe exercise covers a dismantlement inspection within the fictional NuDiVe Treaty. This treaty has not been fully drafted to avoid formulating an overly specific scenario, but important parameters of the inspection regime have been set to position the exercise in the context of the IPNDV 14-step framework for nuclear disarmament. These details are also important within the inspection, as some information and data was be available to the inspectors stemming from inspection activities not played out during the exercise, which they would have to understand and integrate.

The first important aspect to note is that both nuclear weapon states and non-nuclear weapon states are parties to the NuDiVe Treaty and can send inspectors to support the

[1]Synonymous with the German city Jülich, which was the site of the NuDiVe exercise.

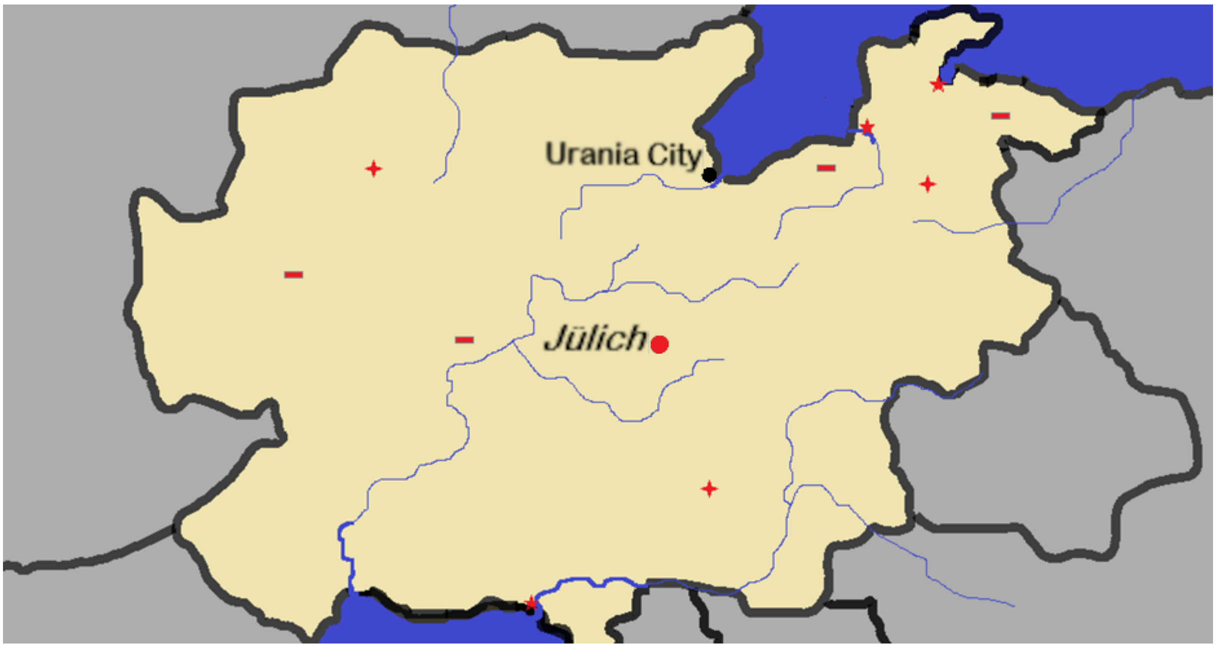


Figure 2.1.1.: The fictional state of »Urania«. The dismantlement took place in the facility at Jülich.

verification regime, mandating the full spectrum of security measures to alleviate proliferation concerns and Urania's need for confidentiality.

The treaty is ambitious in requiring all states parties to reduce their nuclear arsenals to 50 warheads. This provision addresses the often discussed scenario of reducing large arsenals to reach a common limit while retaining a measure of nuclear deterrence, which necessitates an efficient dismantlement regime able to cope with large numbers of warheads. The reduction to zero is not part of NuDiVe as the final step of completely dismantling an arsenal adds an additional layer of urgency and complexity due to the high stakes when the retention of even a small number of nuclear warheads has far reaching consequences.

In the exercise, it was assumed that the dismantlement and inspection regime is already underway and that warheads have been successfully dismantled before, showing the inspectors that a confidence building groundwork has already been laid and that all parties can be assumed to operate in good faith.

Please refer to Appendix A.1 on page 66 and the NuDiVe Report for a detailed description of the three types of inspections assumed in the NuDiVe regime: baseline inspections, inventory inspections and dismantlement inspections.

2.3. Exercise scenario

The concrete NuDiVe scenario encompassed a dismantlement inspection of the dismantlement of one »SH-2« warhead. While it was not the first to be dismantled according to the treaty, is was the first of a batch of the same type in that facility.

One major consequence was that while prior dismantlements might have taken place in the facility, it was also a multi purpose facility which had to be set up for the inspection during the exercise: the inspectors installed the necessary equipment and sealing and dismantled and repackaged it afterwards for potential use in another inspection.

The exercise also presumed that a number of activities had taken place prior to the inspection according to the NuDiVe Treaty. This included the declaration, packaging and sealing of the warheads to introduce them into the chain-of-custody. Data from this process would help the inspectors to verify the identity of the warheads presented to them by comparing their seals and ID tags to the documentation.

The same was true for the equipment, which was presumed authenticated and delivered in sealed boxes.

Also, baseline inspections had taken place before the dismantlement inspection, in which the facility had been assessed to determine and document the rooms to be used, set positions for cameras and portal monitors and draft an initial inspection schedule.

All in all, the following had been handed out to the inspectors:

- An overview of the facilities of the exercise.
- Documentation of the seals/ID placed on the equipment containers and their contents.
- Documentation of the seals/ID placed on the TAI container.

2.4. Dividing Step 8

For the NuDiVe scenario, it was decided to divide Step 8 into two substeps, one dealing with stripping the warhead from high explosives, one to disassemble the rest of the warhead including the fissile material.

This decision was taken after surveying the facilities and reviewing the personnel and time required for dismantlement concluding that dealing with high explosives imposes a number of constraints complicating an inspection. Most notably, for safety reasons, the number of host personnel is limited while inspectors can be allowed even less freedom than in a conventional inspection setting. Also, the required bunkers for handling explosives are quite dissimilar to the radiological facilities available in Jülich.

It was therefore decided to develop and exercise the inspection regime for the latter step 8.2 first, to provide realism while creating a working baseline which can later be streamlined and modified to also fit step 8.1.

2.5. Lessons learned

The evaluation found that the exercise scenario added realism to the exercise and was consistent with the inspection approaches lined out by IPNDV. It was noted by the evaluators that by aligning the inspection goals with the conceptual frameworks developed in IPNDV, and briefing this information thoroughly when moving from paper to practice, the exercise and participants may benefit from the enhanced clarity when planning and executing the minute details of inspection activities.

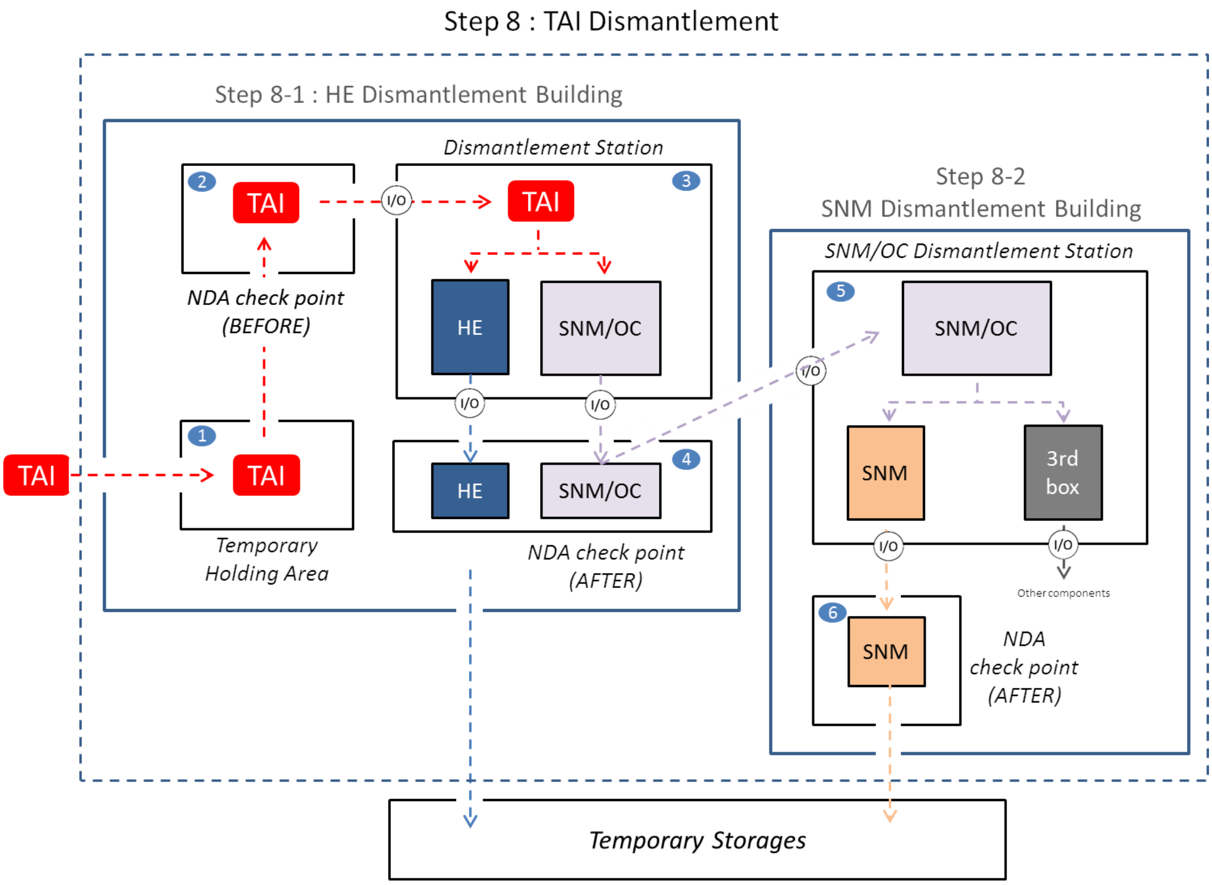


Figure 2.4.1.: Step 8 of the IPNDV dismantlement scheme is condicted in 2 substeps. In Step 8-1, the high explosives (HE) are stripped from the from the rest of the warhead in a dedicated building. The remaining dismantlement Step 8-2 is conducted in the radiation protection area of the dismantlement building, where the special nuclear material (SNM) is removed.

3. Inspection procedure

The NuDiVe exercise had an extremely detailed set of documents describing the whole inspection procedure in great detail, down to single interactions between participants. The reasons for employing this level of detail were several.

Several of the procedures were not trivial to perform according to the numerous requirements, for example with a limited number of inspectors on site. By improvising, participants always face a risk of taking steps which turn out to be impractical or, worst case, invalidate the chain of custody. Providing a thorough, tried and tested description can provide a solid foundation which can be adapted to a specific situation, or which the inspectors can fall back to when in doubt.

Another important aspect is transparency and documentation. The detailed rules of procedure can be consulted, evaluated and discussed by a wider audience not present at the exercise. New ideas and concepts can be brought forward to improve upon the NuDiVe framework, and technologies and methods can be assessed or designed for compatibility with the NuDiVe framework.

The procedures were developed over an extended period, by drafting first concepts which then were discussed, tested and re-drafted in multiple iterations while using tools such as dry-runs, tabletop exercises and boardgames.

3.1. Hierarchy of documents

The inspection procedure has been drafted to provide a framework that is defined in great detail while retaining some modularity to allow adaption to a changing inspection environment and avoid repetition of text. Documents were ordered in a strictly hierarchical manner and cross-referenced extensively. The procedure is distributed among several types of documents.

Step by step document This overview document is a timetable of all the steps required for the inspection. It divides the inspection into a number of substeps. To facilitate planning, it lists the required personnel, equipment and procedure descriptions for each step. In contrast with the procedure descriptions, the steps in this document are designed to be performed in order and they should not be shifted.

Procedure descriptions These contain detailed descriptions of what needs to be done during the inspection. They are divided thematically into 11 documents. Each of these is further divided into tasks which can be used in a modular fashion, in an order determined by the participants. Where required, the equipment manuals are referenced.

Equipment manuals For each piece of equipment, a detailed manual provides information on how it is set up and used.

Behavioural rules Some simple, general rules are laid down to instruct the behaviour of participants according to their roles, especially within the radiation protection area. They were designed to be as simple and universal as possible. More details can be found in Chapter 9.

Dispute settlement Rules for the formal settlement of disputes were included in the rules of procedure.

All of these documents are considered in-game, except for some annotations in the Behavioural Rules. The step-by-step document and the procedure descriptions are compiled in Appendix B on page 76. All manuals are found in Appendix E on page 175, and the Behavioural Rules are in Appendix H.1 on page 235. The dispute settlement procedure can be found on page 83.

3.2. Inspection procedure

The dismantlement procedure has been divided into logical steps for clarity. The steps presented prior and during the exercise can be seen in the document in Appendix B. As these steps have grown over two years undergoing numerous iterations and changes, they have become somewhat uneven, and have been reworked in order to present NuDiVe more coherently to an external audience, while remaining congruent with the inspection procedure. The result of these efforts are the steps as presented in the NuDiVe Report:

1. Arrival and briefing
2. Visit of the facility
3. Commissioning of CCTV and portal monitor
4. Specific check-up of Dismantlement Room
5. Arrival of the nuclear warhead container
6. Arrival of the empty containers: The empty containers for the nuclear and non-nuclear components are transported into the Dismantlement Room. The portal monitor confirms the absence of fissile material.
7. Dismantlement operations
8. Re-establishment of the chain-of-custody on the containers
9. Exit of the fissile material container
10. Exit of the scrap container
11. Exit of the empty treaty item container
12. Specific check-up of Dismantlement Room
13. Decommissioning of portal monitor and CCTV
14. Completion of inspection

Host and inspectors could implement the steps freely, as there were no major logistical time constraints apart from the opening times and the end of the exercise.

3.3. Rules of procedure

3.3.1. Structure

The procedure descriptions were drafted to provide full detail at maximum clarity. For this reason, each procedure description contains a short explanation and overview of its contents and purpose. The appropriate location for each procedure is also listed, if any.

The procedures are roughly divided into actions, each of which references a number of tasks. Each task has a standardised number so it can be referred throughout the document. As the procedures are modular and not necessarily conducted in the listed order, these references are an important feature.

In turn, each task is divided into steps, which are mostly conducted in sequence safe for occasional branching where indicated. Each step has a host and and inspector column, and wherever relevant, the involved personnel are designated using numbers (e.g. »Host1, Inspector2«) to avoid confusion when multiple participants are present. All referenced personnel is accounted for in the personnel requirement given for each procedure.

Any necessary equipment is also listed. Each procedure is complemented by a list of equipment used, which was a useful overview not only for the participants but the organisers, who used these lists to keep track of the equipment they had to obtain and supply.

The host/inspector division was motivated by the fact that in NuDiVe, the inspectors were not allowed to operate any measurement equipment, so most steps involve both parties, the usual order being that the inspector requests a particular action or information to which the host complies by performing said action or supplying said information.

There is also an »events« column with specific situations which may arise during a step, and appropriate actions to be taken. Although many common events are addressed, this is not exhaustive as unforeseen incidents could arise for which the participants need to negotiate on how to proceed, perhaps using the »Dispute settlement« procedure.

3.3.2. Physical document

The Rules of Procedure document was handed out as a physical copy for reference. As procedures are complex and time for training was sparse, having participants memorise the document was out of the question.

In order to be easy to manage on-site, the document was laid out in landscape format and bound using ring binders, so participants could easily flip through the pages and keep them open.

The organisers also considered more complex formats, such as clipboards holding a copy of the procedures as well as a notepad and forms. The idea was deferred as both the procedures as well as the forms were in A4 paper format and would have added to a cumbersome A3 format clipboard, but it could be revisited if the procedures in future exercises fit a smaller format.

3.3.3. Breakdown of procedures

3.3.3.1. Dispute settlement

The procedure on page 83 provides a formal framework for resolving disputes and ambiguities.

This procedure was inspired by the frameworks used in the »START« and »New START« treaties and defines three levels of escalation, always requiring the team leaders to settle the dispute:

1. On-site consultation, in which the current inspection activity is halted and the team leaders are called in.

2. Off-site consultation, in which the team leaders and personnel involved gather to discuss the issue and prepare a report.

3. Incident report, which is prepared by the teams in case the dispute was not resolved and submitted to a higher organ defined in the NuDiVe Treaty.

The dispute settlement procedures are comparatively vague when compared to the more technical procedures. This was intentional as conflicts and ambiguities are inherently unplanned and hard to predict, and the team leaders were to be given leeway to resolve disputes in the most timely manner that they could agree on. The procedure provided the formalities required when the teams could not agree on a common approach.

During the exercise, the »Dispute settlement task 1« was applied on several occasions, »Dispute settlement task 2« only once, and »Dispute settlement task 3« was not required.

Feedback from the participants encourages the development of more specific negotiation procedures for common discussion points such as managed access.

3.3.3.2. Facility entry & exit procedure

The procedure is included on page 89.

This procedure describes how inspectors are meant to enter and exit the facility where during the exercise the simulated dismantlement was taking place. The host teams' entry and exit was not covered here since they were intended to be able to move freely in "their" facility. In fact, they still had to observe the actual entry and exit protocols mandated by Jülich and German Federal radiation protection measures. The mandatory regulations were implemented in the in-game »Facility entry & exit procedure« for the inspectors.

As the exercise was intended to create the feeling of working in a high-security environment, the inspection team had to dress up in protective suits, protection goggles, gloves and overshoes. This was to meet the host's security concerns by not only prohibiting to touch anything inside the facility but actually bar the inspectors from potentially acquiring a swipe sample from the facility.

Another aspect of this measure was to create a »partisan« feeling by creating a clear visual differentiation between the teams but also by making the inspectors feel that they are in the host's facility »following their rules«. For the inspectors, these uncomfortable outfits made the host's power and restrictions tangible, and physically impeded their ability to conduct the inspection.

3.3.3.3. Equipment retrieval and locking procedure

This section concerns the procedure found on page 95.

Equipment authentication is important as equipment used during an inspection in the context of nuclear disarmament needs to be highly reliable while not revealing sensitive information. Both inspectors and host must be certain of the integrity and functionality of the equipment even when it is supplied and operated only by one party.

Authentication can be based on the collaborative construction of equipment before it is put in a chain of custody ensuring that no alternations are made between construction and the use during the inspection. If the host state is the producer and supplier, it could provide multiple instances of the agreed equipment from which the inspection team is allowed to randomly choose one for the use during the inspection and another one for a detailed analysis in their own laboratories.

In case of the NuDiVe exercise it was not feasible to provide the equipment multiple times and authentication was implemented notionally by providing sealed boxes with equipment that was presumed authenticated in a pre-inspection before sealing it away in containers. The participants could access these for the inspection.

During inspection breaks or when leaving the equipment room, situations can arise where the manipulation of equipment is possible. To avoid this, the organisers decided to implement two security mechanisms to guard equipment while it is not in line of sight of the inspectors. Firstly, it could be put back in the appropriate container and re-sealed using the sealing kit. Secondly, the equipment room was under CCTV surveillance to record any unauthorised access.

The interaction between different procedures is obvious here, as seals have to be applied and documented according to the »Seal application task (SAT)« and the »Seal documentation task (SDT)« – both tasks are used in a lot of occasions during the exercise. Also necessary here as in in other situations is the »Memory card operating task (MOT-1)« to transfer the memory card out of the facility. Most photos show seals and are later (in the inspectors' office) checked for damages, changes in the reflective pattern or changes in sealing ID.

Checking and documenting the container seals using the cameras and sealing kit, which are part of the sealed equipment themselves, gives this procedure a certain level of complexity. The first camera was used for taking photos of seals on objects that are to be retrieved or locked. The last photo to be taken with the first camera was then the seal on the second camera. After that, the second camera was used to document the seal on the first camera. This double checking was introduced to make sure that the first camera is not tampered with.

Locking the sealing kit added another layer of complexity. In this case, the memory cards had to be exchanged as well to check the photos after leaving the site. This task had to be executed with the two cameras and photos of the seals had to be taken vice versa. Beyond that, the seals which were to be put on the storage container had to be documented in advance. In consequence, there were no photos of these last container seals. It was therefore of big importance to visually check the seals right before opening the box and to keep the box in the CCTV covered area.

All in all, this led to a lengthy process which got better after some time of practice, but also drew some criticism. While some evaluators and participants felt the procedure was overly complex and paranoid. So far, not alternative idea has been forwarded except relying more on the inspectors' observation and good faith.

This and other aspects of the inspection, for example the security of the inspectors' room, might benefit from some method of taking equipment with the inspectors for safe-keeping, perhaps with a host seal. Creative solutions are encouraged and could potentially speed up equipment related procedures.

3.3.3.4. Visual inspection and photography procedure

Details on this procedure can be found on page 104.

It is intended to take place at the beginning of the inspection to verify the design of the rooms in the way of a design information verification (DIV) common in safeguards activities and to search for potential diversion pathways which are to be documented and later sealed.

Also included is a »General documentation task« applicable to every object of interest to the inspectors if the host agrees. Whether these steps should be established in the framework of a full »procedure« also for a future exercise is to be discussed.

After the exercise, there has been some debate on whether some methods within this procedure produce meaningful results, most notably the knocking on walls. While some nuclear weapons state experts call into question the feasibility of using an actual mallet on the walls of a nuclear weapon facility, participants and evaluators have argued that this method is weak even without the twofold limitation of having a host perform the knocking using only his hand.

3.3.3.5. Data transfer procedure

This section refers to the procedure on page 110.

As a lot of photos, mainly of seals, were taken during the exercise, the data had to be transferred out of the inspection site to the inspectors' office for discussion and verification.

A data transfer via network would have brought about a number of security and confidentiality issues for both parties in a setting where it was considered to sensitive to even provide network access to the inspectors' working computers. It was therefore decided to go with the manual data transfer using a memory card which had been the standard in other disarmament exercises.

For the memory cards from the photo cameras, this process was complex because it was always accompanied by retrieving the second camera (compare »Equipment retrieval and locking procedure« on the preceding page), documenting and breaking the seal of both cameras. Both their memory cards were replaced, then new seals applied and documented. To avoid any potential swipe sample, the memory card exchange happened with disposable gloves and the memory cards were transported in a secure vial (see Figure 6.7.1 on page 42). At the secure boundary the memory cards were scanned for contamination using the actual mandatory Jülich safety procedure and wiped clean with disposable wipes.

The cheating potential was considered small: it might be easy to replace a memory card by a sleight of hand but it is much harder to plant manipulated pictures as the inspectors might recognise the deviation from the pictures they have taken earlier.

The efforts arising from extra measures (clothing of inspectors, cleaning of memory cards, etc.) might be imbalanced with the actual risk of inspectors obtaining a swipe sample from it. Further discussion is needed here.

The process for transferring documents was simpler. They just needed to be placed next to the exit where host team members picked them up to make a photocopy which to be handed to the inspectors. At this point, the host also had the option to redact the data by blackening parts of the document, but this was never used, the reason for this probably being that this would raise contention with little security gain as the inspectors may have memorised that information anyway.

3.3.3.6. Portal monitor procedure

The procedure itself can be read on page 117.

As the scenario encompassed the simulated inspection to be the first of a series of parallel inspections, equipment like the CCTV system and the portal monitor had to be set up for the first time. This procedure describes the commissioning of the portal monitor. It also covers the decommissioning of the portal monitor which is not necessary in case a subsequent inspection takes place. In the NuDiVe exercise, decommissioning was left out due to time constraints.

The portal monitor's thresholds regarding neutron and gamma count rates were set to be sensitive to an amount of 50 g of weapon-grade plutonium.

Early in the exercise, the inspectors requested an event log of the portal monitor to check whether any alarms were recorded overnight. This was spontaneously granted by the organisers, although during the preparations that feature had been initially omitted due to security concerns and is therefore not mentioned in the current procedure. Rethinking the issue with the host team, it was decided such a log provided no additional critical information in addition to the CCTV footage which contained all alarms anyway. Of course, the event log would only contain alarm times, not count rates. The logs were implemented notionally, since no technical implementation for recording the alarms existed at the time, and handed to the participants by the organisers using the form seen in Appendix I.3 on page 274.

The inspectors also asked for a functionality check of the portal monitor with a reference source multiple times during the inspection. This was declined by the host who overlooked that this was indeed a right of the inspectors according to the rules of procedure. At the same time, it would not have been possible for out-game reasons, as the source used for the functionality check was the surrogate source, which was at that time sealed in the container.

For future exercises, these issues should be revisited, and the portal monitor test as well as the event log should be included more explicitly in the procedure description. A dedicated radiation source for calibration and testing should be available. The event log should also be implemented technically, including a procedure on how the participants should obtain and authenticate the logs.

3.3.3.7. CCTV procedure

This procedure is available on page 125.

Commissioning the CCTV cameras had to take place quite early during the exercise because video surveillance was intended as an extra layer of security for the the equipment containers. Therefore the »utility room« was chosen as the first room to set up the cameras. As just two cameras were installed, blind spots might have remained in the utility room, but all equipment boxes were covered.

The CCTV system has proven functional, but the attachment of the cameras requires an overhaul: one camera fell down during the night, creating an incident which needed some negotiations to resolve.

CCTV data was stored in 60 minute files at two terminal laptops in the utility room, one for the hosts to access on demand and one only accessible in the presence of the inspectors as described in the NuDiVe Report. This system was intended to give the host control over the data while providing the inspectors with an authenticated copy untampered with.

The host and inspectors had the option to jointly censor parts of the footage. This feature was contested during the planning of the exercise because in most scenarios, the deletion request alone would raise great suspicion among the inspectors and endanger the positive outcome of the exercise. Even if the chain-of-custody remained intact, the host would have to provide a very plausible explanation to avoid distrust. Still, a deletion option was included because in reality, a nuclear weapon state would require control of the flow of data to avoid the accidental release of classified information.

Data recovery was done by breaking seals covering the data ports of the CCTV terminal and saving the video files on a memory card. The latter is transferred as described in the »Equipment retrieval and locking procedure« on page 20.

As with the portal monitor, decommissioning did not take place in the actual exercise due to time constraints.

3.3.3.8. Handheld neutron/gamma sweeping procedure

This pair of procedures is included on page 134 and 140.

They cover the sweeping scan of the dismantlement room and the corridor in search for neutron sources.

Background measurements which are necessary for the detector to work are implemented in the procedure description as well.

The procedure description was structured as such that even people who have not worked with these particular detectors before should be able to follow the steps, although hands-on training is still considered essential.

Inspectors were meant to compare results from before and after the dismantlement. Due to delays in the course of the exercise, the dismantlement room was not checked after dismantlement. Since it would actually just have been a repetition of the prior procedure it was not considered a big problem to not play it again.

3.3.3.9. Sealing procedure

The sealing procedure on page 144 describes how to apply a seal and how to document and check it.

3.3.3.10. Container movement procedure

The procedure is included on page 149.

This procedure deals with the organisation of how to move the containers, with the treaty accountable item container before the dismantlement and with the component containers afterwards.

Containers have to pass the portal monitor when entering or leaving the dismantlement room by being placed in a marked measurement area for 20 s. The treaty accountable item container was intended to ring the alarms due to the expected presence of more than 50 g of weapon-grade plutonium.

For reasons of confidentiality, the portal monitor was not supposed to show a count rate, however, the portal monitor used in NuDiVe does so on the controller laptop. To alleviate this, the operator controlling the portal monitors concealed the laptop screen from the participants when radioactive sources were in the vicinity. When no radioactive material was present, the screen was regularly observed to ensure that the portal monitors were operating as intended. In future exercises, a more elegant solution should be codified in the procedure, or better yet, a hardware solution to hide the count rate while signalling operation.

3.3.3.11. Host dismantlement room exit and entry procedure

The last procedure can be found on page 155.

To make sure that the host personnel is not smuggling out some parts of the special nuclear material during the dismantlement process, or tries to bring in other nuclear material for reasons of subterfuge, they had to pass the portal monitors in the presence of an inspector.

In the case of an alarm, an additional protocol applied: inspectors would instruct another host to do a body scan with a handheld radiation detector. In practice, only a gamma detector was held ready. If the portal monitors had indicated a violation of the neutron threshold, the inspectors could have requested the neutron monitor.

3.4. Evaluation and lessons learned

While the value of detailed procedures has been acknowledged by both evaluators and participants, they also drew some criticism.

The procedures as such were seen as very complex and hard to grasp, especially if read without a clear preconception of inspection method described. For example, the necessity of some steps might only become clear when witnessing the actual situation. This could be alleviated by detailed training prior to the actual exercise, and by providing a less detailed version of the procedures, or improve clarity by using flow charts and other clarifications.

Another point of criticism was that the procedures seemed to rigid, and participants made a great effort following them by the letter, especially during the first day of the exercise, which may have been detrimental to analysing and negotiating the situation with an open mind.

Responding to this criticism, the organisers suggest it would be best to train participants using detailed procedures, then have them perform the actual inspection more freely with the help of their experience and a more concise procedures document for reference. After developing a routine regarding the procedures, the participants would gain a better overview and capacity for critical thinking and observation when implementing the procedures. The utility of extended training and capacity building was also emphasised in the evaluation.

Another aspect which should be improved is the documentation of previous inspections and their influence on the exercise activities, which has not been systematically presented in one place and was sometimes unclear to the participants. The post inspection goals and activities were also not clearly outlined, meaning it was not completely certain which inspection activities would follow and how the site and materials should be left to prepare them.

At the beginning of the exercise, it was sometimes unclear to the participants how much leniency could be applied in implementing the procedure descriptions, assuming they might be imposed by the overlying treaty and immutable. It was clarified by the organisers that the procedures are only a template for the activities, but IPNDV may wish to consider how this should be treated in general, and whether an inspection mandate stipulates the obligation, or right, to implement the inspection procedure in a specific way.

Regarding the efficiency of the overall procedures, the evaluators felt that a lot could be gained by re-examining the proven process as a whole and develop a »systems approach« in which the inspectors would operate with a more top-down perspective.

Finally, the evaluators propose that IPNDV develop an overarching framework that establishes rights and obligations, inspection types, performance standards, information sharing requirements and other essential elements of a multilateral verification framework.

4. Development and preparations

This section outlines the development progress and milestones of NuDiVe since its inception and project kick-off in 2018.

4.1. Planning timeline

The Foreign Ministry of the Federal Republic of Germany decided in 2017 to contribute to IPNDV by hosting a nuclear disarmament exercise.

Planning started in January 2018 when the two research assistants tasked with the project took office at the Jülich Research Centre and the University of Hamburg. The initial phase was dominated by research of previous nuclear disarmament exercises to determine the scope of the exercise. A leading expert from the UK-Norway and LETTERPRESS exercises was consulted in a workshop within the first few weeks.

Within the next few months, the objective of the exercise was defined. It was to centre around the crucial Step 8 within the IPNDV dismantlement scheme, focusing on absence measurement and averting the diversion of fissile material. These plans were expanded in several meetings.

In May 2018, France joined the exercise and mandated experts from the Ministry of Foreign Affairs and the Ministry of Armed Forces to join the planning group. They contributed the indispensable expertise of a nuclear weapons capable state. At this stage, it was decided to host the exercise at Jülich and the exercise concept was presented to two experts from the UK-Norway, LETTERPRESS exercises, who provided valuable input.

Afterwards, the exercise concept was further refined and the implementation scope of concepts like authentication, sealing, CCTV surveillance and radiation measurements finalised, and the name »NuDiVe« was coined in late 2018. The first complete exercise scenario was drafted and presented to IPNDV. The procedures and manuals were drafted in early 2019.

The final list of participants was announced in April 2019.

At the same time, a thorough fine tuning of the procedures took place in multiple passes. In April 2019, the organisers tested the integrated procedures in a tabletop exercise using floor plans and markers for participants and equipment as illustrated in Figure 4.1.1. In May, the revised procedures were tested in an internal dry run at the Facility in Jülich. An external dry run followed in June, accompanied by six experts with an extensive background in disarmament exercises, treaty inspections and IPNDV. One of them would also be a participant and act as host team leader, profiting from the in-depth knowledge about the site and procedures. Another would strengthen the team of evaluators. This intensive regime of constant testing and reworking assured that the procedure descriptions were sound and interoperating harmonically.

In September 2019, the exercise was conducted as planned.

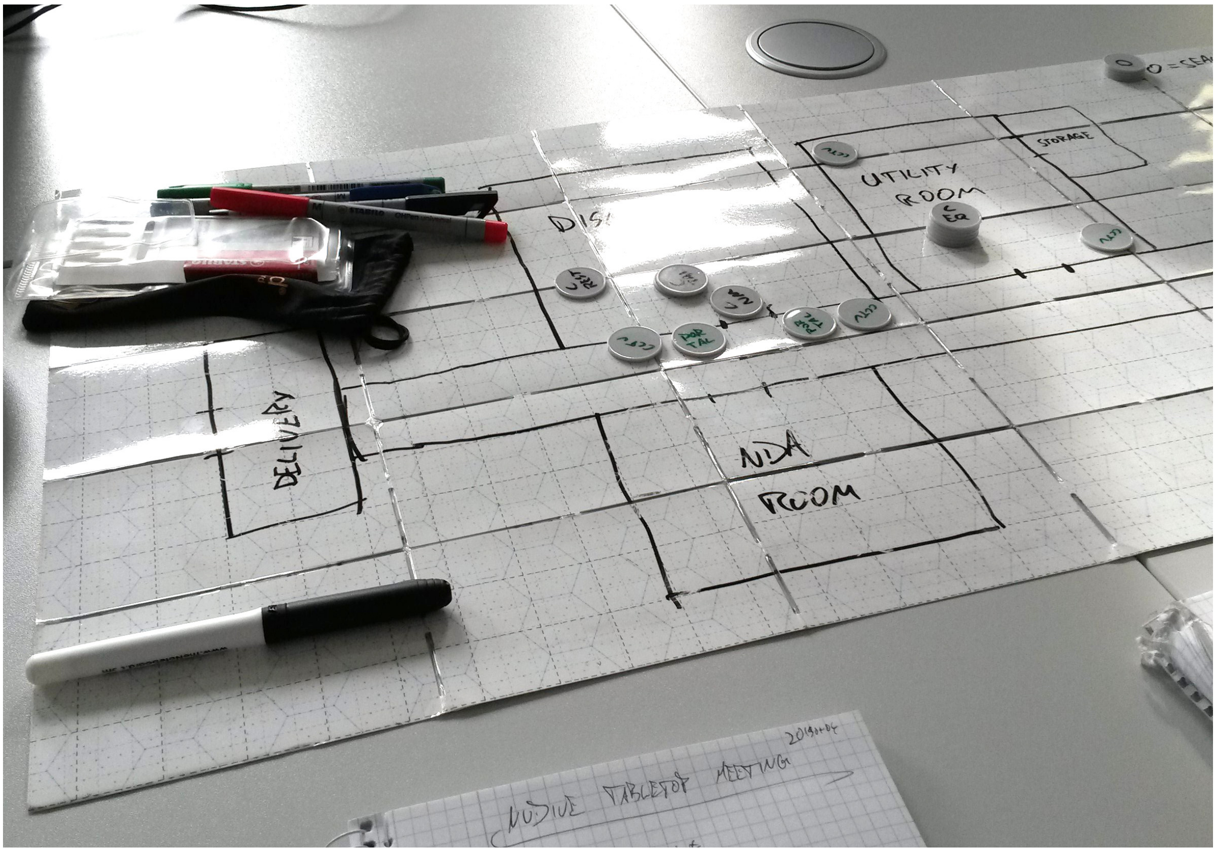


Figure 4.1.1.: The NuDiVe procedures have been played out as a tabletop game to account for exercise logic and logistics.

4.2. Required personnel

The NuDiVe exercise was organised primarily by two research assistants in Jülich and Hamburg, one of whom worked on the project for one and the other for two years. The effort was strongly supported by two German and two French experts participant to IPNDV, as well as one French and one German Foreign Ministry official. Two part-time student assistants were also involved.

In the final 6 months of the exercise, there was significant support form various personnel of the FZ Jülich to organise various aspects, including scientists, radiation protection officers, administrative and catering staff.

4.3. Selection of participants

The NuDiVe exercise was intended to build on and advance the concepts developed in the IPNDV group, test them in practice and set up a concrete, well documented framework for developing dismantlement inspection procedures. It was also intended for capacity building, providing the organisers and participants with valuable experience for future endeavours.

Participation was therefore limited to people involved in IPNDV. Accordingly participants entered the exercise with a profound knowledge of nuclear disarmament principles and methods. To further optimise the skill set and ensure a diverse and balanced distribution within the groups, the organisers accompanied their call for participants by a »Background paper on skills needed for participants« found in Appendix C.1 and required the applicants to fill out the »participation form« in Appendix C.2.

Particularly experienced individuals were sought as team leaders, with many years of experience in all relevant fields such as inspections, exercises, measurement and leadership. They were selected and approached in advance by the organisers.

4.4. Lessons learned

The organisers note that the effort required to develop an exercise from the ground up should not be underestimated, even if it is not the first of its kind. While the development of the scenario and establishment of the general setup are time consuming, a considerable effort and numerous iterations are required to get all the detailed procedures into a state of smooth interoperability. Building on an existing framework may be more efficient, but changes to the procedures should be thoroughly tested using tabletop trials, and are not proven to work before being demonstrated in an integrated exercise.

5. Schedule of the exercise

The out-of-game schedule for the whole NuDiVe exercise can be found in Appendix D on page 169. It laid down all activities planned for participants, evaluators and organisers starting on Day 1, Monday, of the exercise, until Day 5 on Friday.

Participants arrived in their hotels on Sunday 22nd September 2019.

At the Jülich facility, all teams had different arrival times depending on their roles with the host team arriving before the inspectors in order to be present as point of contact and demonstrate their control in all matters of procedure. As described above, all activities were in-game from the time arrival.

Activities generally started at 09:00. Day 1 mainly involved briefing and training activities which continued until Day 2 noon. After lunch, the first contact and common activities were scheduled for host and inspection team. After 16:30, the protected area was closed to the participants and teams were given time for team meetings until the hotel shuttles picked them up.

Inspection activities were scheduled from Day 3 with the teams being relatively free to negotiate and conduct the activities as they saw fit. The organisers were on standby to provide the required services, most importantly providing and transporting the treaty accountable item container and operating the surrogate source. On the evening of Day 3, a reception was held with the visiting ambassadors in which game roles were set aside.

The end of inspection was scheduled to Day 5 noon, after which everyone participated in a 2 hour joint debriefing to collect feedback. Afterwards, the exercise was concluded.

Chapter 10 on page 57 details how the actual inspection exercise played out.

6. Inspection technologies and materials

6.1. Surrogate radiation source

The use of an actual surrogate radiation source was always regarded as an important feature of the NuDiVe exercise. It was chosen to represent the radiative properties of 50 g of plutonium, the significant quantity whose diversion was required to be detectable. It was important to obtain a source which not only had the same strength as plutonium, but also similar emission energies in order to be affected by shielding the same way. By having this source on site, not only could the employed detectors be tested, but the participants could be sure that they had a chance of detecting a diversion effort using the supplied equipment.

Please refer to Appendix E.1 for details on how the surrogate source was quantified and suggestions made for a gamma and a neutron source meeting the criteria. The actual surrogate source was obtained early in 2019 and contained 370 kBq of Cf-252 solution and 3.7 MBq of Ba-133 solution, purchased from »isotrak – Eckert & Ziegler Nuclitec GmbH« in Germany. The isotopes have half lives of 2.6 years and 10.6 years respectively, so they might still be usable in future exercises.

Within the exercise, the surrogate source has only been used sparsely out of radiation protection concerns. It was only removed from its shielding container in critical moments, such as the transport of the treaty accountable item into the Dismantlement Room, but otherwise, especially during dismantlement, it remained shielded.

At one point, the source was used in another capacity, that is as a test source to demonstrate the functionality of the portal monitor as described in the »Portal monitor procedure« on page 117.

There is also the option of using the isotopes in detection exercises to explore diversion scenarios, which has not been a focus of NuDiVe.

6.2. Handheld radiation detectors

Two separate types of detectors were used for absence measurement and to complement the portal monitor in checking personnel and containers moving in and out of the Dismantlement Room, one for gamma detection and one for neutron detection.

6.2.1. Gamma detector

This detector was chosen for its good handling allowing operation with one hand and simple user interface which enables successful operation with a minimum amount of training.

Only the so-called finder-mode (i.e. measurement of gamma count rate) was used. Despite the availability of other more intrusive measurement modes, e.g. isotope identification, only the count rate was shown to avoid displaying classified information.

The detector was provided by the Centre for Science and Peace Research, University of Hamburg.

Handheld gamma detector	
Model:	identiFINDER
Manufacturer:	ICx Technologies
Dimensions:	23.5 cm × 9.3 cm ÷ 7.5 cm
Weight:	1250 g
Detector Types:	NaI(Tl) (∅ 3.6 cm × 5.1 cm) and GM tube (for high dose rates)
Battery life:	8 hours
Energy Range:	30 keV – 3 MeV
Sensitivity (137 Cs):	>500 cps per Sv/h
Alarm indicators:	LED light, sound and vibration

6.2.2. Neutron detector

This detector was chosen for its high sensitivity, clear interface and simple operation via three buttons. It had an integrated Geiger-Müller tube for additional gamma detection which was not used, in order to clearly defer gamma measurement to the more capable NaI detector.

Before the actual measurement a five minute background measurement had to be made to internally calculate an alarm threshold in terms of two standard deviations above the background count rate. This threshold has been chosen so as not to exaggerate type II errors, i.e. to avoid a false negative detection. As the neutron background could potentially be artificially elevated inside the Dismantlement Room a comparative background measurement had to be taken in some other room first. If differences show up or if the background rate in general is suspiciously high, even more preparatory comparative measurements are necessary, which can make the handheld neutron measurement a somewhat lengthy procedure. After these preparatory measurements a sweep measurement of the room is to be done. In case something suspicious shows up, a more reliable time integrated measurement can be conducted.

The neutron detector was provided by the German Federal Office for Radiation Protection.

Handheld neutron detector	
Name:	KSAR1U.06
Manufacturer:	Baltic Scientific Instruments
Dimensions:	30 cm × 16 cm × 13 cm
Weight:	4300 g
Detector Types:	3 He-3 proportional counters (with PE-moderator)
Battery life:	8 hours
Energy Range:	optimized for 10 keV – 1000 keV
Measuring range:	0.01 cps – 6000 cps
Alarm indicators:	LED light, sound and vibration
Static detection sensitivity:	at least 20 cm^2 for fission neutrons

6.2.3. Charging and handling

As both gamma and neutron detector were stored in sealed closed boxes over night, recharging was problematic as it requires connection to a power outlet. The battery life was calculated to be sufficient for the exercise, but for longer operations, a solution must be found.

A problem that came up during exercise is the availability of the neutron detector as a second scanner for entering/leaving host personnel in case of a portal monitor alarm. First, getting them out of the storage box (where they are normally stored) takes time, second, as power on and background measurements take so long it is best to have them running and ready all the time. This on the other hand requires inspector's oversight at all times and tasks the battery even further.

6.2.4. Potential improvements

It was noted that while the handheld monitors were effective, technical improvements are conceivable to adapt them to the task at hand. In particular, they were large and cumbersome to use for the participants especially when scanning high places. At the same time, they provided capabilities such as isotope identification, which is a potential security concern to the host, although during planning the organisers with host state experience voiced no such concerns.

Research is recommended to identify detectors which are more suitable for the specific task of absence measurement using count rate only.

The evaluators also raised the point that measuring the neutron background in a nuclear weapons facility might reveal sensitive information. Again, the NuDiVe organisers saw no such concern when designing the procedure. This highlights that it may be worthwhile for IPNDV to extend research into what kinds of measurements would be acceptable within nuclear state owned facilities, and consolidate these with the requirements of absence measurements.

6.3. Portal monitors

6.3.1. Hardware

The mobile radiation portal monitor system FHT 1378 is a modular, battery-powered measurement system[1] for the detection of gamma- and neutron-radiation. It measures the count rates of both gamma and neutrons which are then displayed in real time on a linked computer. Additionally, alarm lights on top of the detector case start flashing in case the preset alarm threshold is exceeded.

The radiation portal monitor can either be used with one column only or as a combined measurement system with two (or three) identical columns. Mounted onto a tripod, the detector columns can be freely placed wherever needed.

[1] The portal monitor was supplied and operated by the German Federal Office for Radiation Protection.

Portal monitor	
Name:	FHT 1378
Manufacturer:	Thermo Fisher Scientific
Dimensions of column:	130 cm, ∅ 15.5 cm
Gamma detector:	6 L plastic scintillator
dimensions:	100 cm × 12 cm × 5 cm
sensitivity for Cs-137:	35,000 cps/(μSv/h)
Neutron Detector:	He-3 proportional counter
active height:	81 cm
diameter:	5 cm
pressure:	2.5 bar
sensitivity for Cf-252:	120 cps/(μSv/h)
Battery life:	> 200 h
Alarm indicators:	2 LED: blue for neutron, red for gamma

6.3.2. Use in exercise

In NuDiVe, the portal monitor had the dual role of a diversion prevention as well as a chain-of-custody measure. The first was done by using the portal monitor on absence measurement for personnel and containers entering and leaving the Dismantlement Room, precluding the transfer of fissile material. The second role was fulfilled by using the monitor to confirm the presence of radioactive material in the treaty accountable item container entering the Dismantlement Room and the special nuclear material container leaving the room.

After Dismantlement room was cleared, two portal monitor columns were set up to monitor every entering or exiting person or item to check for radioactive materials and avoid diversion. To make measurement more accurate each person or item had to stop within a marked measurement area next to portal monitor for 30 seconds before proceeding. The alarm threshold of the portal monitor was chosen to detect an amount of 50 g of weapon-grade plutonium with little shielding inside the measurement area.

Because of the high detector sensitivity detectors could not be directly placed in front of Dismantlement Room entrance but had to be kept at several metres distance in order not to trigger a continuous alarm when the surrogate source was present inside the room.

During the dismantlement, an inspector had to stand by the portal monitor at all time. This was necessary because in case of an alarm inspector presence was required to clear up the situation and perform follow up scans using handheld detectors. Also, as mentioned in Section 3.3.3.6, the original procedures did not establish the possibility to obtain an alarm event log, so personal presence and CCTV camera footage were the only ways to register a portal monitor alarm. While stationed there, the inspectors had to remain in a designated area where they could not see into the dismantlement room when the door opened.

6.3.3. Lessons learned

The portal monitor was a cornerstone of the inspection logic in NuDiVe. While it was considered effective, they pointed out that the great sensitivity of the portal monitor may lead to false alarms and drawn out negotiations. It might be useful to pursue technical means of limiting the monitor's field of view.

It was also stressed that an acoustic alarm would be useful. Most importantly, an alarm log with timestamps would be a valuable addition. While the CCTVs view of the warning lights is a record of portal monitor alarms, it is accessible only indirectly.

6.4. Seals

Adhesive seals were used to close and control access to doors, containers and diversion pathways. Additional uses were securing the position of stationary measurement equipment like portal monitor and CCTV cameras. The same seals were also used as ID tags for containers and equipment.

6.4.1. Seal types

As this was not intended to be a technology demonstration and because sealing techniques are well practised in the context of safeguards, the NuDiVe exercise focused on the integration and handling of seals rather than employing the most secure seal type available. Another important requirement was that the seals leave no residue in the facility. Commercial adhesive seals with unique numbers and bar codes were employed.

To add another layer of security NuDiVe implemented the application of a so called »reflective particle matrix« to the seals, in the form of commercially available glitter nail polish. By that, a unique pattern of reflective particles was applied onto the seals which is hard to forge.

The adhesive seals were also quite flexible to use, as the reflective particles could be applied before applying the seal. This allowed for uses such as readying and documenting a seal which could then be used to seal the box housing the sealing kit.

6.4.2. Operation

Physical damage to the seals was checked visually during the inspection but could also later be reviewed when the photos of the seals were checked. Beyond that, due to the nail polish the photos were also comparable regarding the reflective particles to see whether the seals remained the same.

To aid the sorting of the numerous seal pictures, a Python software was written and supplied by the organisers which was able to recognize the bar codes and the date of the photo and rename files accordingly. The automated bar code recognition was reliable if the photos were taken so the whole bar code was visible and in focus, and not bent around a corner or too distorted due to a steep viewing angle. To improve photo quality, the procedure contained instructions to take the photo at a distance of 30 cm directly facing the barcode.

The procedure description recommended that the inspectors also note down the seal number, time and location of application, which was necessary to plan each seal inspection and double check the pictures.

To allow for better handling while permitting the inspectors to keep the equipment in line of sight and make sure that no manipulation of the equipment was taking place, the so called »sealing kit« was introduced. This was a transparent bag where the seals,

Figure 6.4.1.: The transparent bag is the »sealing kit« used to carry all equipment needed to apply seals, reflective particle matrix and photo camera. (© Forschungszentrum Jülich / Sascha Kreklau)

the reflective particle matrix but also the camera were stored (see Figure 6.4.1). Bags like these are widely available commercially.

6.4.3. Lessons learned

The sealing strategy of NuDiVe was contentious for several reasons.

One major question raised by evaluators and participants was the security of the seals. While it was not intended to provide the best seal technology available, many felt that not only could the seals have been more secure, but also more varied, with specialised seal types for different purposes. On the other hand, NuDiVe has shown the benefits of using just one method of seal and ID verification, which are ease of use and speed. The teams could always keep the sealing kit on hand and did not have to swap equipment to account for different seal types. After all, swapping equipment was a relatively time consuming process. Just having one technology also meant they required less training and became efficient much faster. It may be desirable to find a middle ground here, with a limited number of seal and ID tag types that provide higher security for specific purposes while still being simple to operate and fitting in one »sealing kit«.

Another point of contention was the number of seals placed by the participants. According to the protocol in Appendix I.4 on page 276, 66 seals were placed and checked, in addition to checking 20 seals already in place at the start of the exercise. 45 of the seals were used to close of potential diversion pathways in the Dismantlement Room. The organisers had already selected a dismantlement room with relatively few features and declared some of the problematic aspects off game, the main example being the ceiling which holds an intermediate ceiling made up of panels, a common feature in laboratories. Still the number of seals could be reduced by providing a more suitable dismantlement room. The organisers highly encourage research for room layouts equally suitable for dismantlement and inspection requirements.

The Evaluators also questioned whether there was a real gain by applying the reflective particles. Other methods with different trade-offs between security and ease of use may have been more suitable.

For future exercises, the organisers recommend including more secure and realistic seal types now that NuDiVe has laid the groundwork and shown how the seals and ID tags can function within a complete dismantlement framework.

6.5. CCTV

The CCTV manual is available on page 219 and describes how to set up the cameras, operate them and extract the footage.

6.5.1. Custody of CCTV footage

During a dismantlement inspection, the host state may require complete control over the footage and only release it after it has been screened for accidentally recorded information that is proliferation relevant or otherwise sensitive. Simultaneously, the inspectors need to ensure the footage handed to them has not been tampered with.

In order to resolve this conflict of interests, a novel method of CCTV footage custody was implemented in NuDiVe. All cameras transmitted their footage to a laptop computer called the »CCTV Terminal« where it was saved. This laptop remained sealed in absence of the inspectors to avert the manipulation of footage. At the same time, the »CCTV Terminal« was transmitting a copy of the footage to another computer, the »Host Terminal«, which was accessible to the host throughout the exercise for screening or retrieving the footage without being able to access the »CCTV Terminal«. This data flow is depicted in Figure 6.5.1.

Whenever the inspectors required access to the footage, they could request the host to open the »CCTV Terminal« and retrieve a copy of the data recorded up to that point to be handed over to them on a memory card.

If the host determined that parts of the footage contained sensible information despite their efforts, they could opt to selectively erase parts of the footage before handing it over. This procedure could only be performed on the opened »CCTV Terminal«, requiring the presence and consent of the inspectors to avoid a critical incident. This option was not used in the NuDiVe exercise.

6.5.2. Hardware

For NuDiVe consumer grade digital cameras of the model »Foscam fi9800p« have been used (see Figure 6.5.2). The idea of using the same equipment as in safeguards was given consideration, but ultimately discarded due to the different requirements.

The laptop terminal were laptops installed with an Ubuntu Linux operating system. They were configured to form a private LAN network when connected with an Ethernet

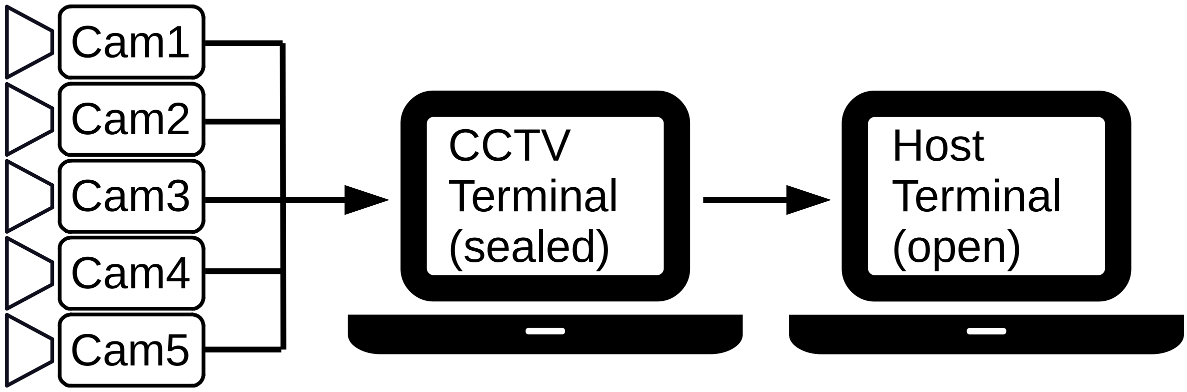


Figure 6.5.1.: The data flow of CCTV footage in the NuDiVe exercise. The two terminals were laptop computers saving the footage. The »CCTV Terminal« was sealed using an adhesive seal, and the »Host Terminal« was constantly accessible to the host team.

Figure 6.5.2.: A CCTV camera used in NuDiVe, mounted to the wall using green adhesive tape and secured with adhesive seals.

cable, and to open a command console and file manager to show the recorded video files and allow the participants to call the scripts required for setup. The inspector terminal would also open a wireless hotspot to which the cameras were configured to connect.

The cameras were communicating using 2.4 GHz wireless network connections. When testing the setup on site, the signal quality was impacted by the long distances, the thick walls and the fact that video transmission requires a high bandwidth. To improve the signal, a wireless repeater module was installed in the hallway, but was not communicated to the participants nor part of the procedure.

6.5.3. Video format and quality

The cameras were configured to send a TV quality signal of 640×480 resolution using the RTSP protocol. Running the CCTV initialisation script starts an instance of the open source software »obs-studio« configured to merge all the streams into a composite stream of 1920×960 resolution including a time stamp, which is in turn forwarded as a stream over the RTP protocol.

That stream is read by an instance of the open source software »ffmpeg« which is saving the video in 1 hour files on the disk, starting a new file every full hour. That process is also forwarding the RTP stream to a new port open to the wired network.

On the host terminal, another instance of »ffmpeg« which is collecting the stream from the inspector terminal and also saving 1 hour files of about 230 MB, or about 10 GB for the whole exercise footage. At the same time, it is forwarding the stream again to an instance of the open source software »cvlc« which displays the video on the screen.

This setup was robust enough to recover from occasional lost frames due to signal loss, and even continued working when one of the cameras failed. On the other hand, it lacked a graphical user interface, was hard to use for the participants and the software framework could be unified to provide more stability.

Using a wired connection would have provided a much better signal quality and less frame loss, but was not possible for the reasons cited below.

6.5.4. Security

The most contentious point regarding security was the decision to operate the cameras via a wireless network. This was mostly mandated by practical reasons, as the safety regulations did not permit using a cable connection because of the doors which must be able to close and drawing a cable beneath them was not possible. Drilling a hole was out of the question, and also not desirable because the whole length of the cable should be visible to the inspectors.

The wireless connection was encrypted using WPA2, which is generally considered secure for long passwords. However, jamming the signal would be relatively easy for the host, and may lead to a signal loss that goes unnoticed if not carefully checked.

The cameras were guarded by observation through other cameras, but did not have a sealed, tamper proof casing.

6.5.5. Camera fixture

Structural alterations like drilling holes were not permitted in the Jülich facility, so the cameras were fixed to a wooden board using screws, which was in turn taped to the wall using adhesive tape. As described in Section 10.2, this was insufficient and one camera fell down within one day.

Another mode of attaching the cameras is advisable. It is realistic to assume that in an actual dismantlement facility, whether multi-purpose or not, an inspection would be of high enough priority to install proper fixtures, but a solution for future exercises in similar environments is also required.

6.5.6. Evaluation of footage

The inspectors' ability to screen the footage was limited by the fact that they could only obtain it hours after it had been taken, only watch in their inspector's room and not take it off-site. Therefore, it was impossible for them to do a complete screening. This was not really necessary, the CCTV surveillance only ever being a secondary inspection technology, but doing a more thorough screen might have provided more confidence according to participants.

Change detection software was not employed. With the wireless connection, image artefacts are common which would have raised more alarms than an inspector could reasonably check. This might be improved by using a cable connection for improved image quality, or by using a change detection algorithm running on the camera. Some cameras offer this, but relying on a closed-source software shipped with the camera would raise additional questions regarding authentication.

6.5.7. Lessons learned

The cameras have done their job and, despite a hardware failure due to the camera fixture, the surveillance regime was robust enough to restore confidence. The inspectors also adopted the strategy of regarding the CCTV system as a secondary layer in their inspection approach. The two-terminal data control system was also successful and accepted by participants and evaluators.

It was commented however by the participants that the failure of the camera fixture had undermined their confidence in the system, and that they were wary of the CCTV footage, momentarily detracting their attention from more significant tasks.

It was also remarked that providing a live stream outside the controlled area would enable additional inspectors to observe critical locations such as the unsealed equipment. However, it is held by the organisers that streaming the footage outside would likely pose a security threat in the eyes of the host state, and that providing the required link would either be another technical challenge to implement in an authenticated trusted manner, or that the forwarding of the footage would rely in infrastructure controlled by the host. With the existing technology, a more ambitious and comprehensive footage review might still be implemented by the inspectors if they can provide the working time.

The following additional technical features were suggested by participants and observers:

- More CCTV coverage would be useful for eliminating perceived dead angles.
- Software may aid the review of camera footage by highlighting movements.
- The camera time signals should be synchronous to the clocks used in other equipment.

Figure 6.6.1.: The transport case of the handheld neutron detector »KSAR1U.06« doubling as sealed container for that equipment. A host is currently taking a photo to record and verify the seal identifying the container. (© Forschungszentrum Jülich / Sascha Kreklau)

For the of reasons outlined above, it is advised to design a more specialised, robust camera system that is tamper proof to a higher degree.

6.6. Containers

6.6.1. Equipment containers

Most of the equipment was stored in simple metal containers as seen in Section 6.9 on page 43. These provided a good stand in for containers with more sophisticated tamper protection, e.g. using optical fibre inlays.

Most of the detectors came in specialised transport cases, which were directly used as sealed containers, like the one seen in Figure 6.6.1. This approach was practical, but underlined the demand for equipment containers that are both suited for the special requirements of the delicate measurement equipment as well as secure.

Despite the seals, there were no security provisions to keep people from opening the containers.

6.6.2. Treaty accountable item container

The container in Figure 6.6.2 was made specifically for NuDiVe and was of cylindrical shape and supported on a movable rack. Its shape resembled containers used in the

Figure 6.6.2.: The container housing the treaty accountable item. It is formed like cylinder and supported by a movable stand. The hatch is sealed and can be used to remove the item from the container. (© Forschungszentrum Jülich / Sascha Kreklau)

QUAD exercise, albeit at a smaller size, because in the NuDiVe scenario the treaty accountable item was already stripped from the high explosive components.

A hatch on the front face of the container opened to a small 30 × 30 cm compartment where the surrogate radiation source could be placed. This hatch could be sealed using adhesive seals. The inspectors would never look inside the container.

The container's materials were mainly metal and wood, with no components with significant neutron or gamma shielding capabilities. The surrogate source would therefore be detected as is, and suitable radiation protection measures were required.

6.7. Data integrity

During the inspection a lot of digital data is accumulated in the form of seal photos as well as CCTV video files. In later exercises, logs from detectors might also be included.

6.7.1. Secure vials

To ensure this footage is not manipulated by the host, the SD cards are transported in a transparent plastic flask that is sealed (see Figure 6.7.1). As SD cards are taken out of the facility numerous times and cannot be brought back in, a stash of empts SD cards is available in the equipment containers.

Figure 6.7.1.: The sealed secure vial used to carry the SD card containing inspection footage from the Equipment Room to the Entry Zone in the hands of a host. (© Forschungszentrum Jülich / Sascha Kreklau)

At the Entry Zone, the SD cards are wiped with swipes to remove potential contamination for security purposes. Afterwards, they are handed over to the inspectors to analyse in their room. They were allowed to copy the data to their working laptops, but could not take media, computers or data off site.

6.7.2. Transferral procedure

On Day 4 (second inspection day) when transferring an SD card within a secure vial out of the controlled area, contrary to what was planned in the procedure description, the secure vial was handled by a host team member. While this did not affect the vial's integrity in a critical manner, it shows the need for a procedure modification or a better explanation between the switch in roles (e.g. »inspector now actively handling an item«). The inspectors found this inconsistent with the claim that inspectors should under no circumstances touch anything in the controlled area.

6.7.3. Cryptography

The data transfer procedure could be simplified if the data was secured using cryptographic methods such as hashes. In practise, the CCTV terminal could calculate secure hashes using, for example, an SHA3 algorithm. The inspectors could then note down the hashes and would not need to rely on keeping the SD cards in sight until they are handed over, instead checking the file hashes on their working laptops to verify the integrity of the data.

Extending this to the photo cameras would require specialised hardware capable of generating and showing cryptographic hashes as the pictures are taken.

6.8. Equipment authentication

Authentication ensures both parties can be confident that inspection equipment will perform exactly as anticipated. This is especially important to the inspectors, who have to be certain that the equipment supplied and transported by the host has not been manipulated.

In NuDiVe, it was assumed that the equipment had already undergone common authentication techniques such as collaborative construction and certification as well as the inspectors selecting among several identical devices. The equipment selected as a result had supposedly been sealed during a pre-inspection. Accordingly, verifying the seals of the equipment boxes was sufficient to confirm that the equipment was authenticated. More information on this procedure can be found in Section 3.3.3.3.

In addition, some basic functionality checks were also performed at the inspectors' discretion, such as verifying the detectors against a test source.

6.9. Equipment organisation

All of the critical inspection equipment was stored in containers in the Equipment Room as seen in Figure 6.9.1. These included containers labelled:

Figure 6.9.1.: The equipment containers as present in the Equipment Room. From left to right: »General Equipment« (seals, photo cameras, SD cards, secure vials, laser distance metre, etc), »CCTV« (CCTV cameras, laptop terminals, cables), »Neutron Monitor 1«, »Neutron Monitor 2«, »Gamma Monitor 1«, »Gamma Monitor 2«. The boxes containing the portal monitors were opposite. (© Forschungszentrum Jülich / Sascha Kreklau)

- »General Equipment« (seals, photo cameras, SD cards, secure vials, laser distance metre, etc)
- »CCTV« (CCTV cameras, laptop terminals, cables)
- »Neutron Monitor 1« (KSAR1U.06)
- »Neutron Monitor 2« (KSAR1U.06)
- »Gamma Monitor 1« (identiFINDER)
- »Gamma Monitor 2« (identiFINDER)
- »Portal Monitor« (portal monitor equipment spread across several sealed boxes)

The containers were sealed, with the seal ID number doubling as an ID for the container. the equipment itself was also sealed and tagged, one example of which can be seen in Figure 6.9.2. In addition to the seals, having the containers in view of the cameras was an important provision to safeguard against manipulation. In practise, it enabled the inspectors to leave the Equipment Room without re-sealing the equipment boxes each time.

Figure 6.9.2.: Like all equipment, this photo camera was tagged with an adhesive seal bearing its ID number. (© Forschungszentrum Jülich / Sascha Kreklau)

At the start of the inspection, the participants received lists of seal numbers from the organisers so they could check the identity and integrity of all the equipment. In the exercise logic, these seals had been applied in a previous inspection during equipment authentication. These lists are shown in Appendix G.

It is notable that while NuDiVe did not generally provide multiple instances of each piece of equipment, there were two handheld gamma and neutron monitors available respectively. This was not primarily intended to act as an authentication measure by giving inspectors a choice in which one to use. Rather, it was to give the participants leeway in how long they wanted to use the monitors in their inspection. Since it was not known whether the batteries of the detectors would suffice, it would have been possible to switch detectors if one had run out. This proved unnecessary in the end. All other equipment did not depend on batteries or did not have a critically low battery capacity.

7. Training

Training of the participants was a significant challenge when organising NuDiVe. Since participants were drafted from IPNDV attendants, they could partake in some related activities within their working hours but they were not professional inspectors so the time they were able to invest in NuDiVe activities was limited.

In practice, participants were able to allot the time for the following activities:

- attend 1 hour pre-briefing events at IPNDV meetings
- study the NuDiVe instruction documents
- attend the 1 week NuDiVe exercise

This meant that time for training was limited and more importantly, hands-on training was not possible before the actual exercise week.

7.1. Briefing

During the briefing sessions, the outline of the exercise was explained based on the »Detailed Draft« in Appendix H.3. Since participants were experts engaged in IPNDV and related work, there was no need to address and explain the fundamental concepts and logic of disarmament verification, enabling the organisers to keep this stage of preparation as brief as it was.

7.2. Preparation

The participants were handed the following documents to prepare for the exercise:

1. Detailed Draft of the exercise (Appendix H.3)
2. Behavioural Rules (Appendix H.1)
3. Exercise Timeline and Procedure Descriptions (Appendix B)
4. Equipment Manuals (Appendixes E.2, E.3, E.4, E.5)
5. Recommendations to team leaders (Appendix H.2, team leaders only)

The documents in points 1 and 2 were read by everyone. Documents in points 3 and 4 were accessible to everyone, but since they were long and complex, the teams were encouraged to find among themselves specialists to for certain procedures and equipment. Document was only accessible to the team leaders and offered advice and off-game information on how to structure and prepare the teams prior to the exercise.

Working through the Procedure Descriptions was particularly challenging for the participants (also see Section 3.4), given their complexity and abstract nature.

7.3. On-site training

The first two days of the exercise were focused on training. Participants had to be familiarised with the equipment and methodology, as well as their surroundings and mandatory safety briefings. Getting to know the facility was particularly important for the host team as they would act as they would have to present themselves as the operators and decision makers.

During the inspection, the hosts would operate the equipment under scrutiny of the inspectors, so both teams had to basically receive the same training, but separately. This was accomplished by enacting the training schedule presented in Appendix F.1 which had the presenters alternating between host and inspectors' room.

The following presentations were given to both teams:

- Behavioural rules
- Safety briefing
- Sealing
- CCTV
- Gamma monitor
- Portal monitor and neutron monitor
- Site visit (host only)

Another important activity during training time was the opportunity for the host team to prepare a site briefing to give to the inspectors on Day 2, and for the inspectors to start work on an inspection plan. The exercise week was the first occasion for the teams to meet and work as a unit despite some short briefings on the side of IPNDV gatherings.

Again, the participants' skill sets would be beneficial as many had previous first hand experience regarding inspections and detection equipment.

7.4. Implicit training

Some actions required specialised training and certain off-game qualifications which could not be trained in the short amount of time and not expected from participants.

One example is the operation of the portal monitor. It had a complex setup routine involving a controller laptop and setting up wireless communication. Since this expensive equipment was a loan from the German Federal Office for Radiation Protection, one of its employees operated the detectors as in-game host technical personnel.

Another example was the surrogate radiation source which was handled and moved by a qualified radiation protection officer from the FZ Jülich to minimize the radiation risk.

7.5. Lessons learned

It was remarked by participants and evaluators that while the training regime was effective in preparing them for the exercise, it was by far not exhaustive and a more in-depth, hands-on training would have done much to give the teams confidence and efficiency from the start of the exercise. In particular, practical training of the procedures was missing so that the according experience could only be gained during the exercise.

Holding the training in-game was confusing to some participants. On the contrary, a more thorough off-game briefing regarding exercise technicalities would have enabled a smoother transition into the roles.

The evaluation report also suggested to not only train participants in advance of an exercise, but to consider regular cadre training for IPNDV experts to build up expertise and regularly engage a wider audience.

8. Site and logistics

8.1. The facility

8.1.1. Jülich campus

The Forschungszentrum Jülich (FZ Jülich, »Jülich Research Centre«) is a large interdisciplinary research centre in the west of Germany. It is a gated campus with an area of over 2 square kilometres housing a number of institutes and large-scale facilities. These surroundings provide a realistic backdrop for a disarmament exercise, as dismantlement would also take place in a secluded, admission controlled facility.

The research centre also features a canteen which the participants could use for lunch, and could supply food to the inspectors who were not allowed to move around on the premises.

8.1.2. Building layout

NuDiVe was conducted in building 05.3 which contained a number of office and conference rooms as well as the laboratory tract, which is a radiation protection area. Both the office and the laboratory area have two floors.

Both floors are connected to the laboratory area. The exercise was organised so the inspectors would be kept apart from hosts and organisers in order to minimise accidental spread of information. This was done by having both the Inspectors' Room and the accessible part of the controlled area in close proximity on the ground floor so inspectors would not have to be escorted far throughout the facility and would not overhear confidential conversations by the other teams.

The laboratory tract could be entered on both ground and first floor. The ground floor entrance was used by host and inspectors, while the entrance on the first floor was used by the organisers when a quick entry was needed.

Both Inspectors' Room and Host Room were large and dominated by tables where the teams could spread their working materials or convene with the other teams. Evaluators and organisers had smaller rooms.

8.1.3. Controlled area

All dismantlement and inspection procedures took place in the Controlled Area. A schematic of the controlled area is shown in Figure 8.1.1.

Within the Controlled Area was the Inspection Area, which encompassed the hallway and all rooms in which inspection activities were to take place, and the only area in which inspectors were allowed if they are accompanied by host personnel. Adjacent to each other were the Dismantlement Room, where the dismantlement took place and which was the focus of the sealing and absence measurement activities. There was also the

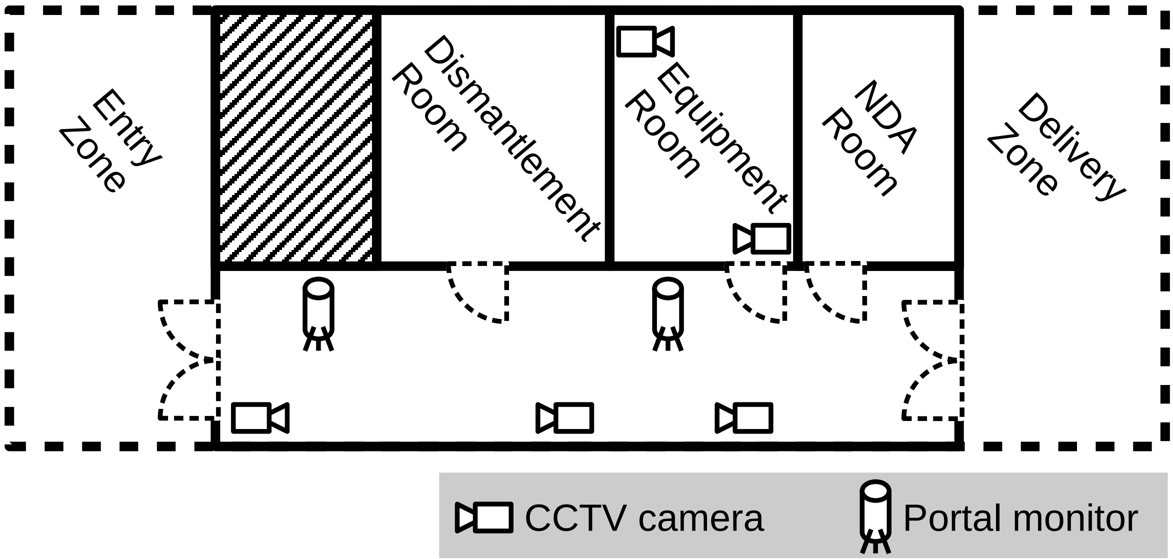


Figure 8.1.1.: Schematic of the controlled area used in the NuDiVe exercise. The positions of the CCTV cameras and portal monitors are marked.

Equipment Room where the equipment boxes were stored. In the NDA Room, a notional NDA measurement could take place, it was therefore empty in the exercise.

8.1.4. Dismantlement Room

The Dismantlement Room (see Figure 8.1.2) was relatively plain compared to the other laboratory rooms. Some features were taken out-of-game using green tape (see Chapter 9) in order to avoid the complexities they would introduce. One example is the ceiling, the sealing of which would have taken up much of the time and provide a security hazard by requiring the use of ladders. Another example are the windows, which where covered by blinds and were treated as walls for in-game purposes.

A number of potential diversion routes remained that required the attention of inspectors. Among these were taps, socket outlets, conduits, the room's relative pressure gauge and more. An empty cabinet stood next to the wall with enough space to inspect its back. There was also a loose but closed container which the inspectors were not allowed to access, supposedly containing tools required for the dismantlement procedure. The organisers foresaw that the operational sink would pose a difficult problem for the inspectors, and anticipated a solution by installing a robust metal grid on top.

The room also contained a small movable dividing wall which could be placed to obstruct an open view from the outside when the door was opened during the dismantlement operation.

8.1.5. Lessons learned

The NuDiVe exercise was intended to feature a multi-purpose facility. This coincided with the fact that the facility at Jülich was also not purpose-built for a nuclear dismantlement inspection, resulting in several of the difficulties outlined above, which in turn provided valuable insight into building features conducive to a successful inspection regime.

Figure 8.1.2.: Participants inspect the Dismantlement Room. (© Forschungszentrum Jülich / Sascha Kreklau)

It was remarked that the rooms are not only complex featuring many potential diversion pathways, but also small easily crowded, severely limiting the potential for groups to operate in parallel. This was also a limiting factor for the entry and exit procedure, for which only a small space was available.

Another obstacle of the multi-purpose facility was that many details were regarded as sensitive by the host, so information was released sparsely and often only after negotiation, thus slowing down the inspection process.

Research is recommended regarding the optimal setup of a dismantlement facility or, if a multi-purpose facility is used, how to optimally document and prepare is for a smooth inspection.

8.2. Radiation protection

The laboratory area was a radiation protection area in accordance with German Federal law. This had a number of implications to the execution of the exercise. As most of these are also to be expected in an actual nuclear weapons establishment, this was a useful guideline for designing the exercise.

When arriving, all participants had to be briefed on how to conduct themselves in a radiation protected area. They had to fill out forms and wear dosimeters on site to satisfy the requirements.

When entering or leaving the radiation protection area, the participants had to use a hand-foot monitor to check for contamination and enter their information in a visitor's book. This happened at the entry area and was also the occasion used to dress the inspectors in their protective suits, gloves and shoe covers. These were not required for radiation protection, but all personnel entering had to at least have a lab coat. Lab coats in team colours (red, blue, green) were handed out to participants for this purpose.

Federal law also required a licensed radiation protection officer present when guests enter the facility.

Another requirement was that the doors be closed at all time to uphold a mandatory pressure gradient between the rooms and the hallway. For this reason, the doors could only be held open for a limited amount of time.

The facility in Jülich was licensed to operate most kinds of radiative material, even fissile material. It was therefore possible to store and employ the surrogate radiation source as described in Section 6.1.

It was mandatory that a radiation protection officer check every item taken out of the area for contamination using a handheld monitor. A dismantlement inspection would be similarly restrictive. In the exercise, there were only two types of item taken out of the area: the SD cards containing footage, which were scanned during the »decontamination procedure«, and the inspectors' notes, which were taken and copied before being handed back to the inspectors. Other items such as pens and clipboards would remain in the entry zone.

8.3. The inspectors' room

The inspectors spent their time either in the inspection area or in their designated room, where they had their working place and equipment. Although their personal electronics were collected upon entry, they were returned shortly and treated as off-game from then on.

NuDiVe adopted a strict information security that did not allow the inspectors to take any information off the facility expect for their reports. Not regulated was the security of the inspectors' notes and working materials for which they initially had no provisions for safekeeping. After some negotiation, they were allowed to seal materials in a cabinet in their room.

This highlights the general need to develop an overarching security concept meeting the needs of both inspectors and host.

9. Game aspects

9.1. In and out of game

Participants in an exercise like NuDiVe have to navigate the superposition of two different perspectives. First, they play a role in the simulation in which they are personnel in a dismantlement inspection within the NuDiVe framework, which can be called the »in-game« perspective. Second, they are participants in an exercise evaluating methods without handling any actual weapons materials, which can be called »off-game« perspective.

The major benefit of an exercise is that every participant can focus on one particular aspect of the whole process. However to do this effectively, they must make a clear distinction as to which elements are off-game. When this distinction becomes unclear or too many off-game elements demand the participants' attention, they may be tempted to prematurely dismiss in-game problems as not relevant, thus restraining their critical thinking.

To counter this phenomenon, the organisers strived for a clear and simple distinction regarding in-game and off-game content. One important measure was the use of actual working technologies wherever possible, so the participants were not tasked with imagining procedures or results. Another was the use of an off-game colour as a clear marker of off-game content.

The off-game colour chosen was green, which was applied in three ways. Areas and structural features were marked using green adhesive tape. Personnel was dressed in green lab coats or shirts which were the standard attire of the evaluators and occasionally donned by organisers when they needed to move around or intervene. Green text and text boxes were used in documents to mark passages containing off-game information. Examples can be seen in Figure 9.1.1, or in Figure 8.1.2 on page 51.

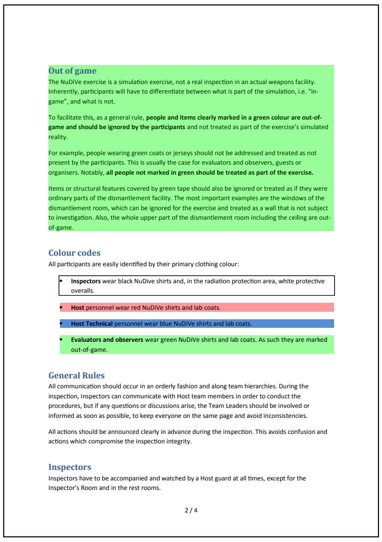
In general, all documents handed to the participants were considered in-game.

In summary, notable off-game elements were:

- all doors not represented in the dismantlement area schematic in Figure 8.1.1 on page 50
- several features of the Dismantlement Room
  - the windows and the blinds covering them
  - the ceiling and everything above a height of 2.5 m

9.2. Roles and Uniforms

NuDiVe adopted colour coded working clothes to make participants' roles easily identifiable. These were communicated to the participants in the »Behavioural Rules« document



Out of game

The NuDiVe exercise is a simulation exercise, not a real inspection in an actual weapons facility. Inherently, participants will have to differentiate between what is part of the simulation, i.e. "in-game", and what is not.

To facilitate this, as a general rule, **people and items clearly marked in a green colour are out-of-game and should be ignored by the participants** and not treated as part of the exercise's simulated reality.

For example, people wearing green coats or jerseys should not be addressed and treated as not present by the participants. This is usually the case for evaluators and observers, guests or organisers. Notably, **all people not marked in green should be treated as part of the exercise.**

Items or structural features covered by green tape should also be ignored or treated as if they were ordinary parts of the dismantlement facility. The most important examples are the windows of the dismantlement room, which can be ignored for the exercise and treated as a wall that is not subject to investigation. Also, the whole upper part of the dismantlement room including the ceiling are out-of-game.

Colour codes

All participants are easily identified by their primary clothing colour:

- **Inspectors** wear black NuDive shirts and, in the radiation protection area, white protective overalls.
- **Host** personnel wear red NuDiVe shirts and lab coats.
- **Host Technical** personnel wear blue NuDiVe shirts and lab coats.
- **Evaluators and observers** wear green NuDiVe shirts and lab coats. As such they are marked out-of-game.

General Rules

All communication should occur in an orderly fashion and along team hierarchies. During the inspection, Inspectors can communicate with Host team members in order to conduct the procedures, but if any questions or discussions arise, the Team Leaders should be involved or informed as soon as possible, to keep everyone on the same page and avoid inconsistencies.

All actions should be announced clearly in advance during the inspection. This avoids confusion and actions which compromise the inspection integrity.

Inspectors

Inspectors have to be accompanied and watched by a Host guard at all times, except for the Inspector's Room and in the rest rooms.

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Figure 9.1.1.: Various off-game elements marked in green, the off-game colour in NuDiVe. To the left of the photo, a door is marked in green tape, signifying that neither it nor its window are part of the exercise's in-game reality. In the centre, an evaluator is wearing a green lab coat, labelling him as off-game entity to be ignored by the participants. To the right, a page from the »Behavioural Rules« document (Appendix H.1 on page 235) contains text marked in green, conveying off-game information and context within a document that is otherwise treated as in-game. (© Forschungszentrum Jülich / Sascha Kreklau)

(Appendix H.1 on page 235) and are listed in Table 9.1. In addition, all participants received name tags. The coloured polo shirts and lab codes were custom made for NuDiVe.

Green is the off-game colour as mentioned in Section 9.1. Accordingly, the evaluators were dressed in green so they could move about freely without confusing the participants. If organisers needed to perform off-game interventions or move about in ways that would upset inspectors, they would don green vests above their lab coats.

Organisers were generally clad in blue and treated as host personnel in-game, albeit as technical personnel that should not interact with the inspectors as possible. This way, the organisers could help the hosts by operating equipment and provide extra hands were needed, such as standing guard outside the inspectors' room.

The inspectors were not free to move about and had to be guarded whenever they were outside the room. This included walks to the toilet, when a host would accompany them down the hallway.

On-site, the inspectors were expected to wear Tyvec coveralls (hazmat suits) as well as taped gloves and shoe covers applied by the host. This proved to be a burden due to the heat and restricted vision. Later in the exercise, as a token of trust, the hosts occasionally allowed inspectors to remove the hoods when they were in visible discomfort.

9.3. Communication

Handheld radios were available to all teams except the inspectors, who depended on being allowed access to the host's means of communication. This also included fixes telephones installed throughout the facility. It was commented that an easier way for inspectors to communicate between inspectors room and inspection area.

Type	Shirt (off-site)	Lab coat (on-site)	In-game designation
Host	red	red	host
Inspector	black	white (coverall)	inspector
Evaluator	green	green	—
Organiser	blue / green	blue / green vest	host technical
VIP Guest	—	grey	—

Table 9.1.: NuDiVe colour codes.

9.4. Team dynamics and psychology

Interactions between inspectors and host in a dismantlement inspection context are not generally adversarial, since they share the common goal of verifying a mutually agreed treaty. Notwithstanding when nuclear weapons are involved, security and secrecy will be rigidly enforced by the inspected state, and security staff may be instructed to prepare for worst-case scenarios such as non-compliant inspectors or even spies. Combined with the fact that the reasons for withholding certain information may themselves be considered confidential, the inspectors may have to face an environment that could seem hostile and obscure.

These aspects were also a part of NuDiVe in order to take into account the friction that may occur on an interpersonal psychological level. The participants were assigned to different locations based on their team affiliation and would only meet in-game. They were also instructed to refrain from conversation between teams that was not necessary for the inspection.

Keeping a professional distance between the teams was generally successful, despite the fact that most participants were familiar with each other due to their shared background in IPNDV. The organisers used several tricks to alienate the teams. For example, the inspectors' freedom was severely restricted while the hosts were allowed to move, and eat, freely throughout the facility, creating imbalance and inequity. The requirement that the inspectors direct all their inquiries at the host also played into this, as when in doubt, the hosts could not plausibly admit ignorance, but had to stall to either come back with an answer later or just block the question. In addition, the host denied requests for information several times by arbitrarily declaring it sensitive.

In effect, the psychological situation and lack of experience regarding the NuDiVe procedures slowed down progress in the first half of the exercise. After familiarising themselves with their roles and motivated by the deadline, the participants picked up the pace and were able to handle negotiations more smoothly later on.

9.5. Continuity

One design goal of NuDiVe was to conduct the inspection in real time to observe the full interaction of procedures and personnel.

This has mostly been successful in the inspection procedure, with two major exceptions. First, the »dismantlement«, i.e. the time in which the Dismantlement Room was closed and guarded by the inspectors, was reduced to about an hour, in which one or two shift changes would take place to demonstrate the principle. Second, the NDA measurements would only take place notionally and be instantaneous.

The exercise continuity would only be interrupted by a common reception in the evening of Day 3.

9.6. Lessons learned

In-game/off-game differentiation was generally handled well by the teams.

Some confusion was reported regarding the dual roles of organisers and host technical personnel, especially during the training when the organisers were not treated as hosts. Starting the exercise after the training would alleviate this issue.

The evaluators saw the value and realism in starting the scenario with an adversarial setup and perceived power imbalance, but pointed out that shifting the focus to a more cooperative approach might allow for a more efficient inspection process. In future exercises, if the main goal is the testing and demonstration of procedures and technologies, it may be beneficial to establish a more cooperative atmosphere from the start, similar to the more lenient interaction the teams displayed in the second half of the NuDiVe exercise. This could also be done by alternating host and inspector roles between teams. Team psychology could be examined in other specialised exercises.

Similarly, in future exercises the organisers may opt to intervene more frequently in order to steer the exercise to reach its specified goals, instead of leaving most judgement calls completely up the participants. This is especially advisable in exercises where participant psychology is no major focus.

10. Course of the exercise

10.1. Proceedings

This section contains a run-down of how what happened during the exercise. Please also refer to the reports by the inspection team in Appendix I.1 for an in-game perspective on the proceedings.

Day 1

Officially, the exercise started »in-game« on Day 1. As such, team contact was always strictly in-game, allowing no informal chats between members of the different teams. Only the training sessions were held on an occasionally informal basis.

There were parallelised training sessions for hosts and inspectors with time-displaced and role-adapted program. The hosts' program laid a focus on practical realisation and familiarisation with the facilities while the inspectors' paid more attention to the inspection logic.

A direct negotiation between hosts and inspectors was not planned for this day by the organisers, but as the in-game scenario had already started, a first negotiation request was expressed. Negotiations were held via telephone and a brief personal meeting at the end of the day.

Request 1 concerned the safe and sealed overnight storage of the inspectors' computers and documents. This was not expected by the organisers nor the hosts and no procedure covering this topic was available. Accordingly, this request remained unsettled until the next day, when the inspectors were allowed to use adhesive seals to seal their notes in a cabinet in their room.

Request 2 was for an early familiarisation visit on the same day. This was refused by the host as the schedule did not foresee this and it was hard to coordinate with the training programme.

Day 2

The concept and planning of the training as well the official host-inspector meeting with introductions and a familiarisation visit for the inspectors was scheduled and went as planned. Inspectors were escorted through the protected area in groups of 3.

Day 3

Procedures 3 (Retrieval and locking), 5 (Data transfer), 6 (Portal monitor) and 7 (CCTV) were completed successfully. Procedure 4 (Visual inspection) was started but not finished due to rejection of the hosts to take photos. Potential diversion pathways were identified and discussed.

Even at this point, the procedure descriptions with their intent to cover all eventualities were perceived as cumbersome at some occasions. Inspectors agreed on shortening some of them in terms of balancing practicability and risk assessment, e.g. CCTV cameras were all attached in one go and only sealed after a shift change, while the procedure description foresaw the sealing right after the attachment of every single camera.

Day 4

In the morning, it was discovered that CCTV camera 1, the leftmost on the floor plan in Figure 8.1.1 on page 50, had fallen from its fixture. The incident was discussed and resolved by remounting the detached CCTV camera and restarting CCTV surveillance.

In parallel, procedure 4 (Visual inspection) was completed under the given circumstances of a lot of difficult pathways to seal.

Sweeping according to procedures 8a and 8b (Handheld neutron/gamma sweeping procedure) was completed. The portal monitor functionality test was object of a long discussion. At first it was denied by the hosts due to a lack of time. Therefore it was agreed to move the treaty accountable item into the Dismantlement Room first and then do the functionality test. However, after moving the treaty accountable item into the Dismantlement Room according to procedure 10, hosts denied the test due to »security reasons«. In reality, the test was not possible because the organisers had not foreseen the requirement and had taken no provisions to enable it.

In addition to that, confusion arose regarding the sealing of the dismantlement room. The teams could not agree on the conditions of how to perform the sealing. This disagreement meant that the treaty accountable item had to be removed from the Dismantlement Room again.

Day 5

In consequence of the dispute regarding the sealing of the Dismantlement Room, the sweeping would have had to be repeated. The organizers shortened this process by notionally implementing it, to give space to procedures not yet performed during the exercise.

After the treaty accountable item had been moved into the Dismantlement Room again, procedure 11 (Host DR exit/entry) was executed. After completing the dismantlement, seals were applied to the containers. Another container movement was not performed because of time constraints. The equipment was locked as agreed and the controlled area was left.

Checks on host personnel should have been done until full clearance of the Dismantlement Room by the inspectors, but were occasionally forgotten. The inspectors later remarked that more reminders in the rules of procedure might have aided them in this hurried phase of the exercise.

The transport of the containers to the Non-Destructive Assay Room, an afterwards sweep of the Dismantlement Room as well as a final check of the seals with subsequent data transfer were also skipped due to time reasons and the fact that these procedures had already been preformed within the course of the exercise.

Decommissioning of CCTV and portal monitor did happen in-game.

As such, the exercise only reached step 8a of 18 total steps while parts of steps 17 and 18 were also completed. It is estimated that the dismantlement inspection could have been

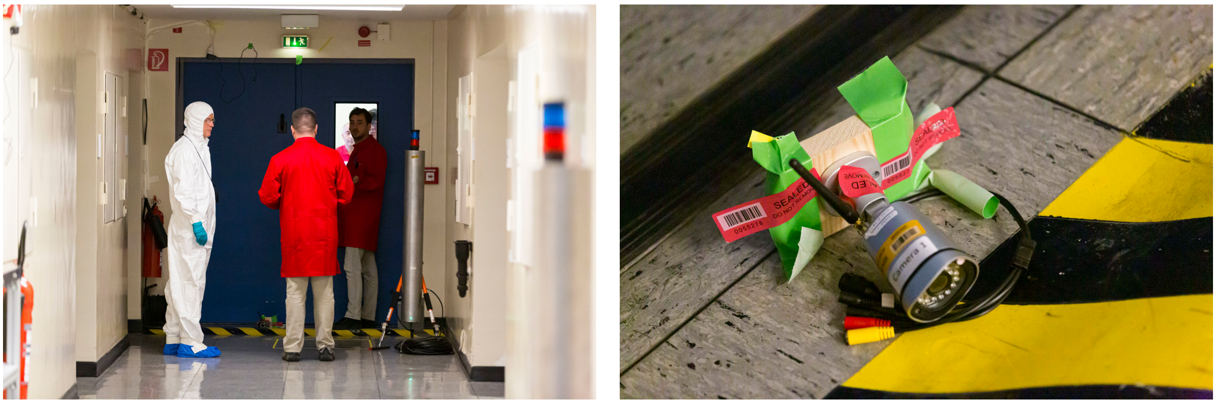


Figure 10.2.1.: One of the CCTV cameras came loose overnight and fell to the ground by accident. The incident was discovered the next morning and the inspection team leader was brought in to investigate. (© Forschungszentrum Jülich / Sascha Kreklau)

played out fully if not for the disputes surrounding the CCTV failure and Dismantlement Room sealing issues,

10.2. CCTV incident

10.2.1. Timing

The incident involving the fallen CCTV camera is well documented in the footage. On Day 3, just after the participants and organisers left, the fixture from CCTV camera 1 started to slowly loosen, the tape holding it slowly loosening under the camera's weight. While it was pointing down the hallway at 17:00, by 18:50 it was already hanging upside down showing the entry door over which it was mounted.

This descent continued until 20:38 when the camera completely dislodged and almost fell, only being held up by the power cable, now showing the hallway again. The power cable was connected to a plug socket, which could not hold the camera up for long. At close to 21:41, the cable slid out of the socket, disconnecting the camera, which only stopped transmitting then. In the footage, the last image remained frozen.

The incident was discovered by the organisers at 8:30 in the morning of Day 4, and reported directly to the hosts upon their arrival 9:00. The team leader of the host delegation checked it immediately, reported to the inspectors and brought in their team leader by 9:40 (see Figure 10.2.1).

The teams moved quickly now and an inspection team was on site to re-establish CCTV surveillance by 9:50. Camera 1 was put back up and reconnected, and the hosts took care to fortify the taping on each camera mount. By 11:00 the surveillance was up again and the inspection proceeded.

Footage from the incident can be seen in Figure 10.2.2.

10.2.2. Background

The incident was entirely due to material failure and, despite many assumptions to the contrary, not planned by the organisers. In fact, internally the organisers had left open

(a) Shortly before the inspection ended for the day, camera 1 was still in position.

(b) After falling from its mount, the camera 1 was hanging upside down sustained by its power cable. The footage is in black-and-white because the cameras switched to infrared mode when the lights went out.

(c) After the power cable tore lose, the picture of camera 1 remained frozen, but its searchlight was no longer visible, as seen on cameras 2 and 3.

Figure 10.2.2.: CCTV surveillance footage from the 5 cameras. Note camera 1 failing over time.

the option of injecting some incident to challenge the teams, but wanted see first how well the participants got along with the schedule.

When the incident was discovered, the organisers decided to go along with it and not interject, as it was foreseeable that the remaining cameras and seals were sufficient to fulfil the requirements of the inspection. The main problem would be the communication and trust between the teams.

10.2.3. Impact

In the footage of CCTV camera 2, the fall of camera 1 was visible despite the darkness and the camera being only on the border area of the image. After failure, camera 1 showed a frozen image, but its failure was still visible to the other cameras because of the vanishing camera light.

The consequences of the camera failure were not grave. All equipment and the Dismantlement Room door were still under surveillance by the other cameras, and no broken seals were found. After reconnecting, the camera was functioning again. Overall, the teams lost about an hour before they could pick up where they left the day before.

10.3. Inspection report

The inspection team was instructed to prepare daily reports of their activities to the headquarters (»HQ«) of the treaty organisation. They are available in Appendix I.1.

Despite the camera incident, they concluded that the dismantlement was successful with no diversion of fissile material.

11. Evaluation and impact

This section outlines the evaluation strategy within NuDiVe and the general results of the evaluation. Detailed evaluation results have already been mentioned throughout this documentation.

11.1. Evaluation methodology

It was clear from the outset that a thorough evaluation would be central to maximise the value of the exercise.

A five-person evaluation team was tasked with observing the exercise and preparing an evaluation report, and given the freedom and support they required. They were supplied with the »Questions for Evaluation of the NuDiVe Exercise« document in Appendix J.1 on page 281 which they used as a basis to prepare a refined set of key questions for gauging the success and lessons learned from the exercise

1. Use and performance of inspection technologies
   a) What do the technologies do well? What do they not do well?
   b) What are the gaps in technical capability and design?
2. Value of inspection approaches and procedures
   a) What do the inspection approaches and procedures do well / not so well?
   b) Were the procedures easy to use and understand?
   c) To what extent were inspection approaches and procedures effective in confirming the object of the inspection?
   d) To what extent were inspection approaches and procedures efficient in minimizing the time and effort needed to complete the inspection?
   e) If applicable, how well were discrepancies resolved?
3. Interaction between the inspection and host teams
   a) How well did managed access measures related to proliferation risk and national security/safety work for the inspected state?
   b) To what degree did security / safety measures impact conduct of the inspection?
   c) What matters needed to be negotiated “on the ground” and were the outcomes mutually satisfactory?
4. Overall assessment of inspection activities
   a) To what degree did the inspection activities provide confidence that state declarations were accurate? Detract from confidence?

   b) How close are we to inspection approaches and technologies that are technically and practically sound?

5. Assessment of the exercise scenario design, venue and organisation for testing IPNDV and ideas
   a) Was the exercise effective for testing IPNDV-developed verification concepts?
   b) What lessons are there for future exercises?
   c) Was the training on the procedures / technologies adequate to accomplish the exercise objectives?
   d) Was useful knowledge shared between the NNWS and NWS participants?

In addition to their observations, the evaluators handed out questionnaires to the participants before and after the exercise.

On the last day, the evaluators gathered everyone involved for a »hot-wash« discussion of the exercise while their impressions were still fresh and present.

11.2. Evaluation results

The report by the evaluation team is available in Appendix J.2 on page 284.

In summary, the evaluation team noted that the participants were satisfied and considered the dismantlement inspection according to the procedures successful. They also noted that NuDiVe was an effective implementation of IPNDV-developed inspection concepts and forwarded several remarks to improve the efficiency and effectiveness of the procedures, equipment and exercise methodology. The importance of »moving from paper to practice« was stressed, along with the critical role practical exercises play in this regard.

Regarding equipment, it was noted that the systems employed were effective prototypes that would benefit from research and development to arrive at technologies that are truly robust and specialised for the requirements of a dismantlement inspection. This was particularly stressed for the CCTV surveillance system, the portal monitors and adhesive seals.

It was also stressed that more work is needed within IPNDV to consolidate inspection and security requirements, particularly with respect to facility design and the unintended disclosure of classified information through background measurements, absence measurements and other means.

Research should also be conducted regarding the overall framework of a verification regime and how the supplied information, procedures and inspection goals should guide and instruct the inspection process.

11.3. NuDiVe documentation

The organiser team prepared extensive reports containing many of the documents, inspection framework and procedures to offer transparency and a comprehensive foundation for future work within the IPNDV.

11.4. Further work

The organisers are preparing a new and improved NuDiVe exercise at the time of writing.

Acknowledgements

The authors wish to thank the German Federal Office for Radiation Protection for supplying and operating most of the radiation detection equipment. The exercise benefited from the invaluable advice and input from Tore Ramsøy, Michael Edinger, David Chambers, Alicia Swift, Jens Wirstam, John R. Walker, Alex Bednarek and Steinar Høibråten. Last but not least the organizers thank all participants – without their motivation and engagement this exercise would not have been possible.

A. Scenario documents

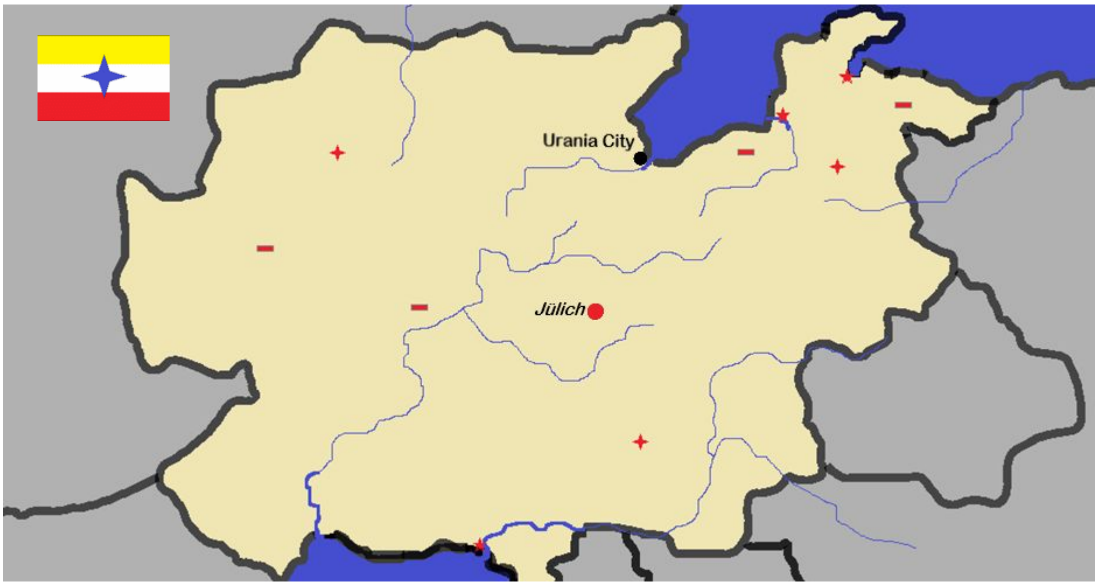
A.1. NuDiVe Treaty background information

NuDiVe
Nuclear Disarmament
Verification

NuDiVe Treaty background information

General information on Urania:

Full name: Republic of Urania;
Inhabitants: ca. 100 millions;
Capital: Urania City;
International commitments: UNSC permanent member, NPT signatory weapon State
Nuclear arsenal : Global stockpile of 1000 warheads, of which 830 are deployed : 140 on aircrafts (cruise missiles), 140 on SLBMs, and 550 on ground-based ICBMs.



Army base

Navy base

Airforce base

Nuclear weapon campus

1

The NuDiVe Treaty:

Treaty general background: All NPT NWS are members of the NuDiVe Treaty, along with a significant number of non-nuclear weapon States (NNWSs), and agreed to reduce their arsenals to 50 warheads per NWS. As the verification protocol has been agreed by States parties, the first warheads are about to be dismantled simultaneously in the different States.

The verification protocol was built foreseeing three types of inspections to verify to whole dismantlement process:

- Type A - Baseline inspections: these inspections are facility-focused, and take place to assess the facilities associated with the treaty (declared design verification), to jointly decide and set up verification equipment in facilities (CCTV cameras spots, measurement equipment location…), and more generally to prepare future disarmament inspections in said facilities ;
- Type B – Inventory inspection: these inspections are focused of the flow of items within the disarmament process. These inspections are used in order to introduce declared TAI into the verification system (CoC, measurements) through initialization steps. The same type of inspection is used to follow items after dismantlement has occurred.
- Type C - Dismantlement inspection: these inspections are focused on the dismantlement process and follow (CoC) and/or measure (NDA, presence and absence measurements…) the treaty accountable items (TAI) as it goes through the dismantlement process. They are aimed at assuring the continuity of CoC throughout the dismantlement process. **The NuDiVe exercise will display a Type C inspection.**

Urania treaty background: Urania is a NPT signatory nuclear weapon state (NWS). In an approach towards nuclear disarmament, all NPT NWS negotiated and joined a multilateral nuclear disarmament treaty called the NuDiVe Treaty. A significant numbers of non-nuclear weapons States (NNWS) are parties to this NuDiVe Treaty, which aims at reducing all nuclear arsenals to 50 warheads, under a strict verification regime.

In accordance with its obligations originating from the NuDiVe Treaty, Urania allows multilateral inspections (Type A, B and C) to verify the different processes pertinent to the elimination of nuclear warheads. This process takes fully into account the principle of non-proliferation and concerns related to national security, as well as safety and security regulations. These inspections are implemented on the basis of an agreed verification arrangement, pursuant to the NuDiVe Treaty.

Urania nuclear warhead dismantlement is implemented within a military campus used for multipurpose activities related to the monitoring of its nuclear arsenal, in Jülich.

2

General information on TAIs:

The declared treaty accountable items (TAIs) to be dismantled on the side of Urania are nuclear warheads of different types composing its nuclear arsenal[1]:

- 10 SH-1 warheads in inactive stockpile (formerly mounted on GKP-2 aircraft-launched cruise missiles);
- 145 SH-2 warheads mounted on GKP-3 aircraft-launched cruise missile, including 125 deployed;
- 10 N2 warheads in inactive stockpile (formerly mounted on S1 SLBMs)
- 125 N3 warheads mounted on Neptune-S2 SLBMs, including 80 deployed;
- 60 N4 warheads mounted on Neptune-S2 SLBM, including 25 deployed;
- 50 A1 warheads in inactive stockpile (formerly mounted on ground-based Juno ICBMs);
- 550 A2 warheads mounted on ground-based Jupiter ICBMs.

In Jülich **for the NuDiVe exercise**, dismantlement operations under the NuDiVe Treaty will deal with type *SH-2* warhead (explosive yield of ca. 150 kt TNT) which are mounted on aircraft-launched cruise missiles of type *GKP-3 Vreddesbringer*. The special nuclear material used within these warheads is weapon-grade Plutonium.

Origin of the warhead:

Twenty SH-2 warheads were separated from their GKP-3 *Vreddesbringer* vectors on the aircraft base without an inspection team allowed to be present (Step 1). Inspectors – a team composed of members of all signatory states except Urania – had first access to the TAIs already loaded into containers in the temporary storage at the deployment site (Step 2 – Type B inspection). There, the first team of inspectors performed a non-destructive assay (NDA) on the TAIs and could confirm the presence of plutonium. Thereafter the devices were loaded into special transportation containers of type *C-1* designed by the Uranian autorities. They meet the safety specifications of all States included in the treaty. They are equipped with a optic fiber tamper indication system, a tumbler tamper indication system and accelerometers (which do not transmit the data out of the C-1 container but store it for a later check-up). In this sense, the chain of custody (CoC) was established.

Transfer to Jülich:

From that point, the TAIs in C-1 containers were transported under military protection to the multipurpose dismantlement campus in Jülich– (Step 3/5). Inspectors were not present during the transfer. At the facilities, the TAIs were loaded into temporary storage sites which are under CCTV surveillance (Step 6). Right after the arrival, a second inspecting team (Type B inspection) checked the integrity of the CoC by reviewing transfer information, tags and seals.

[1] For more information about Urania nuclear arsenal, see document « NuDiVe In-game Urania weapons numbers »

3

At the facility:

At the multipurpose campus in Jülich special operational rooms were set up for the purpose of dismantling the TAI. In parallel other operations like maintenance and refurbishment of warheads may take place.

After the check-up of tags and seals (CoC check) performed by the inspectors (Step 6), the TAI was then moved to the Dismantlement buildings with the inspectors being present (Step 7).

The inspectors thus have just restricted access to the declared facilities where the high-explosive (HE) dismantlement and the special nuclear material (SNM) dismantlement are separated. In Jülich, the dismantlement operations take place in two separate buildings for two distinct steps: Step 8.1 (separation of HE from the TAI) and Step 8.2 (separation of SNM and other materials). Each of this step is inspected in order to confirm complete dismantlement of the weapon.

Previous measurements:

NDA check: Using a jointly designed information barrier, attribute measurements are performed, protected by information barriers: determination of presence/absence of plutonium and isotopic ratio of plutonium-239 to plutonium-240 via passive gamma radiation measurements and determination of minimum plutonium mass via a passive neutron measurement.

NDA measurements are made at the arrival of the TAI in Jülich just before Step 8.1, just after Step 8.1 and after Step 8.2 on the separate containers.

Necessary Documents:

Before Step 8: TAI and C-1 container description, First NDA protocol, CoC protocol and reporting for each TAI (unique identifiers, tags, CoC establishment).

A.2. TAI documentation

Unclassified – MoFA
Version: 07-2019

NuDiVe
Nuclear Disarmament Verification

Doc. No. C413217785

Ministry of Foreign Affairs
Republic of Urania

NuDiVe Treaty

Information sheet

GKP-3 *Vreddesbringer*

2018

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The nuclear explosive devices (NEDs) declared by Urania in the NuDiVe Treaty are nuclear weapons of different types.

One of the declared weapon type is the *SH-2* warhead (explosive yield of ca. 150 kt TNT) mounted on aircraft-carried cruise missiles of type *GKP-3 Vreddesbringer*. The special nuclear material used within these warheads is weapon-grade Plutonium.

Data for **GKP-3:**

Length	7 m
Diameter	0.72 m
Weight	1.270 kg
Range	1.500 – 2.500 km
Speed	250 m/s (900 km/h)
Propulsion	Schlum-Tech Corp. turboreactor (liquid fuel)
Warhead	SH-2 thermonuclear (150 kT)

A.3. Urania weapon inventory

NuDiVe Treaty
Urania nuclear weapons systems

	platform					Delivery systems					Warheads*									NuDiVe Treaty	
														deployed warheads		inactive					
	Designation	total built	active	inactive	destroyed	Designation	total built (inc test rounds)	active	inactive	destroyed (inc in tests)	Designation	total built	tested	Deployed active warheads	Deployed reserve	Inactive reserve	Inactive stockpile	Disassembled	Remaining total	Total to be disassembled	Final limit
Aircraft	**Honeybee**	60	0	4	56	GKP-1	120	0	0	120	SH	80	5				0	75	0	0	0
	Wasp	100	0	20	80	GKP-2	200	0	0	200	SH-1	150	5				10	135	10	10	0
	Dragonfly (N	40	20	20	0	**GKP-3**	120	50	60	10	**SH-2**	165	5	80	60	10	10		160	145	15
Submarine	**Kraken**	7	0	5	2	Neptune-S1	60	0	10	50	N1	100	5					95	0	0	0
											N2	30	5				10	15	10	10	0
	Leviathan	**8**	**2**	6	0	Neptune-S2	70	20	40	10	**N3**	130	5	30	50	20	25		125	125	0
											N4	100	5	40	20	10	25		95	60	35
Ground-based						Juno	180		150	30	**A1**	605	5				50	550	50	50	0
						Jupiter	165	150		15	**A2**	555	5	500	50				550	550	0
Experimental Test Objects												45	45						45		
											totals	**1960**	45	**650**	180	40	130	**870**	**1045**		
														830		**170**					
														1000						**950**	**50**

*Warhead Status

Status	Description
Deployed Active	Fully operational warheads Mated to delivery system. For SLBMs, the S2 missile is always loaded onto submarine if armed with warheads. For ALCM, the CMN2m is assigned to a specific Hornet [N] delivery system.
Deployed reserve	Fully operational warheads Ready to be mated to delivery system
Inactive reserve	Warhead with some mechanical parts removed to maintain system health whilst in storage. Held in storage at base. Can be made active rapidly in case of necessity.
Inactive stockpile	Warhead held in central location. Some parts removed to maintain system health whilst in storage. Stockpile aiming at being dismatled.
Disassembled	Weapon system broken down into fissile and non-fissile components. Explosives no longer associated with fissile material. Any or all components may either be in storage, recycled or destroyed.

B. Procedures and dismantlement steps

Dismantlement Steps and Procedures

NuDiVe
Nuclear Disarmament Verification

This document contains detailed instructions on how to perform the verified nuclear dismantlement within the NuDiVe framework. The procedures have been previously agreed by the parties to the NuDiVe treaty and should allow for a reliable verification of the dismantlement operation. Based on this guideline, the Inspectors and Inspected State Party (Host) will agree on the implementation and schedule of dismantlement and inspection activities.

The document consists of two sections:

1 Dismantlement Steps

This table presents a general overview on the steps taken, listing the appropriate procedures to be carried out as well as the minimum amount of personnel required for executing the tasks. When making adjustments, the teams need to bear in mind the maximum number of inspectors allowed in the facility. All procedures mentioned in the table are detailed in the following section.

2 Procedure Descriptions

The preface of each Procedure Descriptions gives information on the intent of the procedure, as well as the required personnel and locations. It is followed by an overview table listing the Actions commonly contained in the procedure. It commonly includes a number of Tasks which are detailed below and which contain detailed instructions for Host and Inspector personnel. The Tasks will not necessarily be conducted in the order presented: they may be referenced multiple times in the same Procedure, and may even be referenced in other Procedures; the teams may apply each Task whenever required.

NuDiVe – Dismantlement Steps

Step	Title	Actions	Equipment	Implementation measures / procedures / manuals	Hosts required	Inspectors required
Disclaimer: High explosive (HE) dismantlement has been executed beforehand.						
Start of SNM/OC dismantlement						
1	**Safety instructions**	Verification of the safety accreditations/ individual clearances *(not simulated)*				
		Presentation of the facility *Facility authority*		**I) Presentation of facility** - General purpose of the facility (explanation of the different facilities for SNM and HE) - Descriptive plan - Map of the SNM-facility - Activities in the facility - Equipments - Functions of the host personnel	All present	All present
		Presentation of the inspection team *Inspection team leader*		**II) Presentation of inspection team** - Inspection team members (functions) - Equipments to be used	All present	All present
		Presentation of safety instructions *Facility Authority*		**III) General safety presentation** - Fire safety, emergency exit procedures, maximum number of people, conditions for safe movement in facility, first responders procedures…	All present	All present
				IV) Radiation protection instructions (types of radiation, dosimetry, allowed operations, I/O controls…)	All present	All present
		Presentation on inspection modus operandi *Host team leader*		**V) General briefing on managed access** - Who does what ? - How ? - Under whose supervision ? - Forbidden actions (accesses, equipment use…)? - Critical steps	All present	All present
				1) Dispute settlement procedure - Triggering of non-compliance suspicion process as enshrined in the verification agreement - includes on-site and off-site consultations	All present	All present

2	**Visit to the facility**	**Familiarisation visit** *Inspection team*	Standard inspection suits	**2) Facility entry & exit procedure** - Entering radiation protection area - Host Team collects documentation from Inspection Team	1 to escort Inspectors from inspector's room to radiation protection area(RPA). 1 to dress inspectors. 3 inside RPA to meet the inspectors that enter the RPA	3 per tour until all have seen the facility
			Floor plan	**Familiarisation tour** - following *I) Presentation of facility*	3 inside radiation protection area	3 per tour until all have seen the facility, inside radiation protection area
3	**Commissioning of CCTV and portal monitor**	**Set up of CCTV system to supervise Utility room and entry to SNM-dismantlement room (DR)** *Inspection team, equipment handled by host team*	Camera no. 1 and 2 CCTV cameras CCTV terminals	**3) Equipment retrieval and locking procedure** -Retrieval of material from storage box	2 in Utility Room	2 in Utility room
			CCTV terminals CCTV cameras CCTV mounts	**7) CCTV procedure** - Commissioning of CCTV system	2 in Utility room and hallway	2 in Utility room and hallway
		Visual check: identification of diversion pathways *Inspection team, equipment handled by host team*	Camera Inspection logsheet	**4) Visual inspection and photography procedure** - Verification of structural design - Verification of present objects - Search for potential diversion pathways - Documentation of pathways	2 in DR	2 in DR
			Camera no. 1 and 2 Memory cards Secure Vial Sealing kit	**5) Data transfer procedure** - Recovery of memory card - Memory card transfer *Placed here exemplarily, can be executed whenever inspectors consider it to be necessary*	4 (2 inside, 2 outside of radiation protection area)	3 (2 inside, 1 outside of radiation protection area)
		Set up of an entry and exit control for the DR to detect any SNM leaving or entering the room *Inspection team, equipment handled by host team*	Portal monitor	**6) Portal Monitor procedure** - Commissioning of portal monitor (done by technical personnel) - Functional test of portal monitor with test sources	3 in Utility room and hallway	2 in Utility room and hallway
4	**Specific check-up of dismantlement room (DR)**	**Application of seals on the potential diversion pathways of DR** *Inspection team, equipment handled by host team*	Clipboard Inspection logsheet Camera Adhesive seals Reflective particle matrix	**9) Sealing procedure** - Search for potential diversion pathways - Application of adhesive seals and reflective particle matrix - Documentation of sealing	2 in DR	2 in DR

		Screening of the SNM-dismantlement building (including DR and sealed empty containers) *Inspection team, equipment handled by host team*	Handheld gamma detector Handheld neutron detector	**8a) Handheld neutron sweeping procedure** **8b) Handheld gamma sweeping procedure** - Preparatory neutron background measurements - Scanning the room for neutron and gamma sources	2 for 8a in hallway and DR 2 for 8b in DR	2 for 8a in hallway and DR 2 for 8b in DR
5	**Arrival of the item in the delivery zone**	**Containers for SNM and other components (OC) are in their temporary storage area in DR** *(not simulated, implemented by the host team)*				
6	**SNM/OC container moved to DR** *Non destructive assay (NDA) has been performed on SNM/OC container after step 8.1*	**SNM/OC container passes portal monitor** *Container moved by host team*	Portal monitor	**10) Container movement procedure** - SNM/OC container with SNM/OC passing portal monitor and entering dismantlement room	1 to move SNM/OC container outside portal monitor controlled area 1 to move container inside that area 2 at portal monitor	2 at portal monitors
		Verify chain of custody (CoC) via seals / unique identifier *Inspection team, equipment handled by host team*	Camera	**9) Sealing procedure** - Documentation of sealing on container (CoC verification)	2 execute SDT 2 at portal monitor	1 executes SDT 2 at portal monitor
7	**Dismantlement operations**	**Dismantlement operations** *(Implemented by the host team)*			3 in DR 2 at portal monitor	2 at portal monitor
		Shift changes *Host team members and inspection team members can be replaced on site as required*	Portal monitor Gamma detector Neutron detector Telephone	**11) Host DR exit/entry procedure** - Outward transfer of host personnel - Inward transfer of host personnel	>1 in DR 2 at portal monitor 1 entering or leaving DR	2 at portal monitor
				Inspection team shift change: **5) Data transfer procedure** **2) Facility entry & exit procedure**	1 to accompany inspector 1 at controlled boundary 2 at portal monitor	1 to enter/leave radiation protection area 2 at portal monitor

8a	**Reestablishment of the chain of custody on the containers (SNM, OC)**	**Application of tags and seals on the containers** *Inspection team, equipment handled by host team*	Clipboard Inspection logsheet Camera Adhesive seals Reflective particle matrix	**9) Sealing procedure** - Seal application on containers - Documentation of sealing for CoC verification	2 execute SAT and SDT in DR 2 at portal monitor	2 execute SAT and SDT in DR 2 at portal monitor
8b	**Transfer of SNM container to NDA room**	**Container passes the portal monitor** *Host, under inspectors' scrutiny*	Portal monitor	**10) Container movement procedure** - SNM Container leaving the dismantlement room	2 move container(one inside & one outside portal monitor controlled area) 2 at portal monitor	2 at portal monitor
9	**Non-Destructive Analysis (NDA) performed on SNM container**	*(not simulated)*				
10	**Transfer of SNM container to delivery zone**			**Container movement** - SNM container moved from NDA room to delivery zone	2 move container 2 at portal monitor	2 at portal monitor
11	**Transfer of OC container to NDA room**	**Container passes the portal monitor** *Who ? Host, under inspectors' scrutiny*	Portal monitor	**10) Container movement procedure** - Non-SNM-Container (OC) leaving dismantlement room	2 move container(one inside & one outside portal monitor controlled area) 2 at portal monitor	2 at portal monitor
12	**NDA performed on OC-container**	(not simulated)				
13	**Transfer of OC container to delivery zone**			**Container movement** - OC container moved from NDA room to delivery zone	2 move container 2 at portal monitor	2 at portal monitor
14	**Transfer of empty SNM/OC container to NDA room**	**Container passes the portal monitor** *Host, under inspectors' scrutiny*	Portal monitor	**10) Container movement procedure** - Non-SNM-Container (OC) leaving dismantlement room	2 move container(one inside & one outside portal monitor controlled area) 2 at portal monitor	2 at portal monitor
15	**NDA performed on empty SNM/OC container**	*(not simulated)*				

Dismantlement Steps, page 5

16	**Transfer of empty SNM/OC container to delivery zone**			**Container movement** - Empty SNM/OC container moved from NDA room to delivery zone	2 move container 2 at portal monitor	2 at portal monitor
17	**Specific check-up of DR**	**Screening of DR** *Inspection team, equipment handled by host team*	Clipboard Inspection logsheet Camera Distance meter Handheld gamma detector Handheld neutron detector	**3) Equipment retrieval and locking procedure** - Retrieval of material from storage box **4) Visual inspection and photography procedure** - Verification of information observed prior to dismantlement	2 in Utility Room 2 at portal monitor	2 in Utility room 2 at portal monitor
			Handheld gamma detector Handheld neutron detector	**8a) Handheld neutron sweeping procedure** **8b) Handheld gamma sweeping procedure** - Preparatory background measurements - Searching room for hidden SNM	2 for 8a in hallway and DR 2 for 8b in hallway and DR 2 at portal monitor	2 for 8a in hallway and DR 2 for 8b in hallway and DR 2 at portal monitor
		Verify the seals *Inspection team, equipment handled by host team*	Clipboard Inspection logsheet Camera	**9) Sealing procedure** - Documentation of sealing	2 execute SDT 2 at portal monitor *(relieved after this step)*	2 execute SDT 2 at portal monitor *(relieved after this step)*
18	**Decommissioning of portal monitor and CCTV**	**Withdrawal of entry and exit control** *Inspection team, equipment handled by host team*	Portal monitor	**6) Portal monitor procedure** - Decommissioning	3 in hallway and Utility room	2 in hallway and Utility room
			CCTV terminals CCTV cameras and equipment	**7) CCTV procedure** - CCTV data recovery - Decommissioning of CCTV system	2 in Utility room and hallway	2 in Utility room and hallway
			Camera Memory card Secure Vial	**5) Data transfer procedure** - Recovery of memory card - Memory card transfer - Document transfer	3 (2 inside, 2 outside of radiation protection area)	3 (2 inside, 1 outside of radiation protection area)
			Handheld gamma detector Handheld neutron detector Sealing kit	**3) Equipment retrieval and locking procedure** - Locking of material in storage container	2 in Utility Room	2 in Utility room
			Standard inspection suits	**2) Facility entry & exit procedure** - Exiting radiation protection area	≥1 inside RPA, 2 outside RPA at controlled boundary	all remaining

Procedure description: 1) Dispute Settlement

Purpose of the procedure

The Dispute Settlement Procedure enables the Inspectors to resolve disputes and ambiguities that could potentially weaken the outcome of the inspection. Any Inspector may raise an objection at any time, whereupon the Host will halt the inspection if possible and try to clarify the issue on the spot. If this is not successful, or if the issue is only noticed later on, it can be recorded and raised again outside the radiation protection area. If the following consultations still cannot clarify the issue, it will be noted in the inspection report, commented by the host and brought up in a committee as established by the underlying disarmament treaty.

This procedure comprises different tasks: Dispute settlement task 1 (DST-1), Dispute settlement task 2 (DST-2), Dispute settlement task 3 (DST-3)

Location

This procedure takes place wherever an issue arises.

Participants

Inspector1 raising the issue.
Any affected **Host** personnel.
Inspection Team Leader and
Host Team Leader should be called in as soon as possible.

Procedure description: 1) Dispute Settlement — Procedure **1**, page **2**

No.	Action	Hosts	Inspectors	Equipment
I	On-site consultation	*Position according to current task*	*Positions according to current task*	Inspection Logsheet
			Inspector1 notices irregularity or similar problem. Inspector1 exclaims “*We have a question. Please halt the activity.*”	
		Addressed Host halts current activity if possible. Host Team Leader is informed	Inspection Team Leader is informed	
		Host Team Leader executes Dispute settlement task 1 (DST-1)	Inspection Team Leader executes Dispute settlement task 1 (DST-1)	
If issue is declared resolved during on-site consultation, the procedure is finished. Otherwise, proceed with action II.				
II	Off-site consultation	*Meeting Room*	*Meeting Room*	Inspection Logsheet
		Host Team Leader and affected Host execute Dispute settlement task 2 (DST-2)	Inspection Team Leader and Inspector1 execute Dispute settlement task 2 (DST-2)	
III	Incident Report	*Hosts’ Room*	*Inspectors’ Room*	Inspection Report
		When preparing Inspection Report, after inspection is finished, Host Team files issue as described in Dispute settlement task 3 (DST-3)	When preparing Inspection Report, after inspection is finished, Inspection Team files issue as described in Dispute settlement task 3 (DST-3)	

List of tasks

Step	Hosts	Inspectors	Equipment	Event	Provision to be taken in case of event
DST-1 Dispute settlement task 1					
	Host Team Leader and other Hosts. Position according to current task	*Inspection Team Leader and other Inspectors. Position according to current task*			
1		Inspection Team Leader, aided by Inspector1, explains problem and how it may affect outcome of Inspection			
2	Host Team Leader considers issue and tries to negotiate a compromise			Inspection Team Leader believes issue is resolved	Inspection Team Leader declares issue resolved, **End of Dispute Settlement**
				Issue not resolved	Continue Dispute Settlement Procedure
3		Inspector1 notes incident in inspection logsheet	Inspection logsheet		
END of DST-1					

Step	Hosts	Inspectors	Equipment	Event	Provision to be taken in case of event
DST-2 Dispute settlement task 2					
	Host Team Leader and involved Host(s) in meeting room	*Inspection Team Leader and involved Inspector(s) in meeting room*			
1		Inspection Team Leader requests conflict resolution from Host Team Leader and gathers all Inspectors involved in issue			
	Host Team Leader gathers Host personnel involved in issue if possible				
2	Inspection Team Leader and Host Team Leader discuss issue and try to find solution. This may include agreeing on alterations to some remaining inspection procedures, inclusion of additional inspection procedures or other measures		Inspection logsheet	Inspection Team Leader believes issue is resolved	Inspection Team Leader declares issue resolved, **End of Dispute Settlement**
				Issue not resolved	Continue Dispute Settlement Procedure
3		Inspection Team Leader notes result of consultation in inspection logsheet	Inspection logsheet		
4 ***(if additional measures were agreed in step 2)***	Host Team Leader distributes information about additional measures to all Host personnel	Inspection Team Leader notes additional measures in inspection logsheet and briefs Inspection team accordingly	Inspection logsheet		
END of DST-2					

Step	Hosts	Inspectors	Equipment	Event	Provision to be taken in case of event
DST-3 Dispute settlement task 3					
	Host Team Leader and involved Host(s) in Hosts' room	*Inspection Team Leader and involved Inspector(s) in Inspectors' room*			
1		Inspection Team Leader gathers all Inspectors involved in issue and drafts statement for inspection report			
2	Host Team Leader and Inspection Team Leader discuss issue and exchange views				
2	Host Team Leader informs Inspection Team Leader on intended statement in inspection report	Inspection Team Leader informs Host Team Leader on intended statement in inspection report			
3		Inspection Team Leader writes appendix to inspection report detailing issue	Inspection report		
3	Host Team Leader writes comment to said appendix, detailing view on issue, which is also added to inspection report				
END of DST-3					

Appendix: List of materials

- Inspection logsheet
- Inspection report

Procedure description: 2) Facility entry & exit procedure

Purpose of the procedure

The Inspection Team is required to follow certain procedures when entering or exiting the radiation protection area. This document describes the necessary actions for any Inspection Team member to enter or exit the radiation protection area. The Inspection Team must comply with the 'Behavioral Rules' documentation.
Special care will be taken during this procedure to ensure that no documentation is improperly taken out of the radiation protection area.
Special care will also be taken to ensure the standard inspection suits, gloves and overshoes are removed from the Inspection Team and no swipe samples could be taken out of the radiation protection area.

Remarks

Host's entering and leaving process of the radiation protection area is not described here as it does not require Inspectors' attendance. All Hosts escorting Inspectors inside the radiation protection area are expected to be already inside the area at the beginning of this procedure. Analogously, the Host personal outside the area necessary for the exit process has to be informed early enough to position itself at the boundary of the radiation protection area on time. In order to speed up the entrance process by preparing inspection suits and overshoes beforehand the Hosts should know/request each inspector's suit and shoe size.

This procedure comprises two tasks: Inspection team entrance task (IET-1), Inspection team exit task (IET-2).

Location

This procedure takes place at the main entrance/exit of the IEK-6 radiation protection area.

Participants

Host1 (or as many Hosts as necessary) inside the radiation protection area.
Host2 outside the radiation protection area.
Host3 outside the radiation protection area, supporting Host2 during the exit process.
At least one Inspection Team member to enter or exit the radiation protection area, hereafter referred to as **Inspector1**.

Procedure description: 2) Facility entry & exit procedure | Procedure **2**, page **2**

No.	Action	Hosts	Inspectors	Equipment
I	Entering radiation protection area	*Host1 at controlled boundary, Host2 outside radiation protection area*	*Inspector1 outside radiation protection area*	
			Inspector1 requests access to radiation protection area	
		Host team leader designates who to accompany Inspection team member(s) to enter radiation protection area		
		Host1 and Host2 execute Inspection Team Entrance task (IET-1)	Inspector1 executes Inspection Team Entrance task (IET-1)	Standard inspection suit Standard inspection gloves Standard inspection overshoes Tape Dosimeter Hand and Foot Monitor
Repeat action I for every Inspector to enter facility				
II	Host Team collects documentation from Inspection Team	*Host1 inside, Host2 outside radiation protection area*	*Inspector1 inside radiation protection area*	
			Inspector1 requests to leave radiation protection area	Phone Inspection logsheet Clipboard Trays for pens and clipboards
		Host1 phones Host2 and asks Host2 to prepare Inspector's exit		
		Host1 instructs exiting Inspector1 to place all documentation in designated area in preparation of Document transfer task (DTT)[1] and all pens and clipboards in designated tray	Inspector1 places all documentation in designated area and all pens and clipboards in designated tray	
III	Exiting radiation protection area	*Host1 inside, Host2 and Host3 outside radiation protection area*	*Inspector1 inside radiation protection area*	
		Host1 escorts Inspector1 out of radiation protection area	Inspector1 gets escorted out of radiation protection area	
		Host1, Host2 and Host3 execute Inspection Team Exit task (IET-2)	Inspector1 executes Inspection Team Exit task (IET-2)	Hand and foot monitor Scissors Refuse bin Soap Paper towels
Repeat action III for every Inspector to exit facility				

1 *see*: Procedure description: 5) Data transfer procedure

List of tasks

Step	Hosts	Inspectors	Equipment	Event	Provision to be taken in case of event
IET-1 Inspection team entrance task					
	Host1 at controlled boundary, Host2 outside radiation protection area	*Inspector1, maybe more Inspectors, outside radiation protection area*			
1	Host1 prepares inspection suits, gloves and overshoes for expected Inspector(s)		Inspection suit, Inspection gloves, Inspection overshoes		
2	Host2 meets Inspector1 at entrance of radiation protection area, verifies ID and escorts Inspector1 through security door to radiation protection barrier cupboard		Inspector's ID		
3		*If Inspector carries document(s):* Inspector1 puts document(s) at designated spot	Documents		
4 ***(if not already done that day)***	Host2 assigns dosimeter, fills out radiation protection log sheet with Inspector1's information and prepares a lanyard with dosimeter and Inspector's ID	Inspector1 signs radiation protection log sheet	Dosimeter assignment list, Dosimeter, Radiation protection log sheet, Lanyard		
5	Host2 organizes and monitors Inspector1's use of hand and foot monitor	Inspector1 uses hand and foot monitor	Hand and foot monitor	Hand and foot monitor alerts	Dispute settlement procedure
6	Host2 dresses Inspector1 with new inspection suit, gloves and overshoes		Inspection suit, Inspection gloves, Inspection overshoes, Tape		
7	Host2 checks inspection suit is taped into sleeves of inspection gloves and into inspection overshoes				
8	Host2 hangs lanyard with ID and dosimeter around Inspector1's neck		Lanyard, ID, Dosimeter		

Procedure description: 2) Facility entry & exit procedure — Procedure **2**, page **4**

Step	Hosts	Inspectors	Equipment	Event	Provision to be taken in case of event
9		*If required:* Inspector1 picks up pen and clipboard from tray as well as brought along documents	Pen, Clipboard, Documents		
10	Host2 guides Inspector1 to Host1 waiting behind door to radiation protection area				
Repeat steps 1 to 8 for every Inspection team member					
11 ***(once all Inspection team members are dressed and wear dosimeters)***	Host1 permits escorted entrance to radiation protection area				
	At least one Host team member escorts one Inspection team member	Every Inspection team member is escorted by at least one Host team member			
End of IET-1					

Step	Hosts	Inspectors	Equipment	Event	Provision to be taken in case of event
IET-2 Inspection team exit task					
	Host1 inside radiation protection area supervising waiting Inspectors, Host2 (at controlled boundary) and Host3 outside radiation protection area	*Inspector1 inside radiation protection area*			
1	Host2 meets Inspector1 at exit of radiation protection area, while Host1 and remaining Inspectors wait inside radiation protection area	Inspector1 leaves radiation protection area and goes to controlled boundary			
2	Host2 recovers dosimeter. It will be analyzed and results will be communicated to Inspector later		Dosimeter, Dosimeter assignment list		
3	Host2 removes inspection suit, gloves and overshoes by cutting them off with scissors making sure to avoid any contact of suit's exterior with cloths of Inspector1		Scissors	Suit is damaged	Decontamination
4	Used inspection suit, gloves and overshoes are disposed into designated bins. Care is taken so that Inspector1 does not handle inspection suit, gloves and overshoes		Refuse bin		
5	Host2 organizes and monitors Inspector1's use of hand and foot monitor		Hand and foot monitor	Hand and foot monitor alerts	Dispute Settlement procedure
		Inspector1 uses hand and foot monitor			
6	Host3 organizes and monitors hand washing		Soap, Paper towels		
		Inspector1 enters washroom and washes hands			
	Host3 ensures paper towels are disposed in designated bin				
Repeat steps 1 to 6 for every Inspector to exit facility					
End of IET-2					

Appendix: List of materials

- Radiation protection log sheet
- Standard inspection suit
- Standard inspection overshoes
- Standard inspection gloves
- Tape
- Dosimeter with lanyards assigned to each Inspection team member
- Dosimeter assignment list
- Pens (stored inside radiation protection area)
- Clipboards (stored inside radiation protection area)
- Trays for pens and clipboards
- Hand and Foot Monitor
- Scissors
- Refuse bin for inspection suits, gloves and overshoes

Procedure description:

3) Equipment retrieval and locking procedure

Purpose of the procedure

During the dismantlement process the inspection team needs different types of authenticated equipment. To ensure the integrity of the equipment this equipment will be stored in sealed storage boxes when not in use. This document describes the actions to retrieve and to lock any kind of equipment from/in the storage box.

This procedure comprises two tasks: Equipment retrieval task (ERT), Equipment locking task (ELT).

Location

This procedure takes place in the Utility room, a CCTV supervised area.

Participants

Host1 to perform the main retrieval/locking actions.
Host2 to assist Host1 and (if already retrieved) carrying the sealing kit.
(More Hosts if necessary to handle more objects)
Inspector1 as the leading inspector.
Inspector2 to keep the minutes (inspection logsheet).

Procedure description: 3) Equipment retrieval and locking procedure — Procedure **3**, page **2**

No.	Action	Hosts	Inspectors	Equipment
I	Retrieval of material from Storage box	*Host1, Host2 in Utility room*	*Inspector1, Inspector2 in Utility room*	Inspection logsheet Object *(Handheld gamma/neutron detector, CCTV cameras, etc…)* Sealing kit
			Inspector1 asks Host1 and Host2 to execute Equipment retrieval task (ERT)	
		Host1 and Host2 execute Equipment retrieval task (ERT)		
		Host2 holds *object(s)* such that they stay in line of sight of Inspector2	Inspector2 maintains *object(s)* always in line of sight. If necessary Inspector2 reminds Host2 to secure line of sight	
II	Locking of material in Storage box	*Hos1, Host2 in Utility room*	*Inspector1, Inspector2 in Utility room*	Inspection logsheet Object *(Handheld gamma/neutron detector, CCTV cameras, etc…)* Sealing kit
			Inspector1 asks Host1 and Host2 to execute Equipment locking task (ELT)	
		Host1 and Host2 execute Equipment locking task (ELT)		

List of tasks

Step	Hosts	Inspectors	Equipment	Event	Provision to be taken in case of event
ERT Equipment retrieval task					
	Host1, Host2 in Utility room	*Inspector1, Inspector2 in Utility room*			
1 ***(if sealing kit is already at hand)***		Inspector1 asks Host2 and Inspector2 to execute Sealing documentation task (SDT) on seals of storage box	Camera, Inspection logsheet		
	Host2 executes Sealing documentation task (SDT) on seals of storage box	Inspector2 executes Sealing documentation task (SDT) on seals of storage box			
2		Inspector1 asks Host1 to break seal of storage box		Seal previously damaged or broken	Dispute settlement procedure OR Withdrawal of storage box and implementation of backup box
	Host1 breaks seal of storage box				
If sealing kit is already outside the box: *continue with step 7*					
3		Inspector1 asks Host1 to affix broken seal on *broken seal documentation sheet* and note time and previous place of attachment	Broken seal documentation sheet, Pen		
	Host1 affixes broken seal on *broken seal documentation sheet* and notes time and previous place of attachment				
4		Inspector1 asks Host1 to retrieve sealing kit from storage box	Sealing kit		
	Host1 retrieves sealing kit from storage box and hands it over to Host2				
5 ***(if sealing kit is retrieved first time)***		Inspector1 asks Host1 to retrieve second camera from storage box	Second camera (No.2)		
	Host1 retrieves second camera from storage box				
		Inspector1 asks Host1, Host2 and Inspector2 to execute Sealing documentation task (SDT)[1] with	Camera No.1, Camera No.2,		

Step	Hosts	Inspectors	Equipment	Event	Provision to be taken in case of event
		camera No.1 on seal of camera No.2 and vice versa	Inspection logsheet		
	Host1 and Host2 execute Sealing documentation task (SDT) with camera No.1 on seal of camera No.2 and vice versa	Inspector2 executes Sealing documentation task (SDT)			
		Inspector1 asks Host1 to put camera No.2 back into storage box	Camera No.2		
	Host1 puts camera No.2 back into storage box				
6		Inspector1 asks Host2 and Inspector2 to execute Sealing documentation task (SDT) on broken seal of storage box	Inspection logsheet, Camera No.1		
	Host2 executes Sealing documentation task (SDT) on broken seal of storage box	Inspector2 executes Sealing documentation task (SDT) on broken seal of storage box			
If sealing kit is already outside the box proceed from here					
7		Inspector1 asks Host1 to retrieve *object*	*Object*		
	Host1 retrieves *object* from storage box				
8		Inspector1 asks Host2 and Inspector2 to execute Sealing documentation task (SDT) on object	Camera, Inspection logsheet		
	Host2 executes Sealing documentation task (SDT)	Inspector2 executes Sealing documentation task (SDT)			
9	Host1 keeps *object* in line of sight of Inspector1			Interruption of line of sight	Inspector2 checks identification number of *object* OR Dispute settlement procedure
***Repeat steps 7 to 9 for every object** which needs to be retrieved from storage box*					
10		Inspector1 asks Host1 to close storage box and to put it in CCTV cameras' field of view			
	Host1 closes storage box and puts it into CCTV cameras' field of view				

1 *see*: Procedure description: 9) Sealing procedure

Step	Hosts	Inspectors	Equipment	Event	Provision to be taken in case of event
11 ***(if Inspection team will leave Utility room afterwards)***		Inspector1 asks Host1 to execute Seal application task (SAT) on storage box	Adhesive seals, Reflective particle matrix		
	Host1 executes Seal application task (SAT) on storage box				
		Inspector1 asks Host2 and Inspector2 to execute Sealing documentation task (SDT)	Camera, Inspection logsheet		
	Host2 executes Sealing documentation task (SDT)	Inspector2 executes Sealing documentation task (SDT)			
End of ERT					

Procedure description: 3) Equipment retrieval and locking procedure — Procedure **3**, page **6**

Step	Hosts	Inspectors	Equipment	Event	Provision to be taken in case of event
		ELT Equipment locking task			
	Host1, Host2 in Utility room	*Inspector1, Inspector2 in Utility room*	*Storage box in CCTV supervised area*		
1 ***(if storage box is sealed)***		Inspector1 asks Host2 and Inspector2 to execute Sealing documentation task (SDT) on seals of storage box	Inspection logsheet, Sealing kit		
	Host2 executes Sealing documentation task (SDT) on seals of storage box	Inspector2 executes Sealing documentation task (SDT) on seals of storage box			
2 ***(if storage box is sealed)***		Inspector1 asks Host1 to break seal of storage box and affix it on *broken seal documentation sheet*	Broken seal documentation sheet	Seal previously damaged or broken	Dispute settlement procedure
	Host1 breaks seal of storage box, affixes it on *broken seal documentation sheet* and notes time and previous place				
		If only camera (sealing kit) is going to be locked: *continue with step 9*			
3		Inspector1 asks Host2 and Inspector2 to execute Sealing documentation task (SDT) on identification seal of *object* that is to be locked	Camera, Inspection logsheet, Object	Identification number of *object* does not match with earlier noted number	Dispute settlement procedure
	Host2 executes Sealing documentation task (SDT) on identification seal of *object*	Inspector2 executes Sealing documentation task (SDT)			
4		Inspector1 asks Host2 to put *object* in storage box	*Object*		
	Host2 puts *object* in storage box				
		Repeat steps 3 and 4 for every object *which needs to be locked in storage box.* *If* ***sealing kit is going to be locked*** *follow steps 9 to 14.* *If* ***sealing kit is <u>not</u> going to be locked*** *follow steps 5 to 8.*			
5		Inspector1 asks Host1 to close storage box			
	Host1 closes storage box				

Step	Hosts	Inspectors	Equipment	Event	Provision to be taken in case of event
6		Inspector1 asks Host2 and Inspector2 to execute Seal application task (SAT)	Sealing kit		
	Host2 executes Seal application task (SAT) on storage box	Inspector2 executes Seal application task (SAT) on storage box			
7		Inspector1 asks Host2 and Inspector2 to execute Sealing documentation task (SDT)	Camera, Inspection logsheet		
	Host2 executes Sealing documentation task (SDT)	Inspector2 executes Sealing documentation task (SDT)			
8 ***(if not already CCTV supervised)***		Inspector1 asks Host1 to move storage box into CCTV supervised area	Storage box	**End of ELT**	
	Host1 puts storage box in CCTV supervised area				
If sealing kit is going to be locked proceed from here					
9		Inspector1 asks Host1 to prepare one adhesive seal to later seal storage box	Adhesive seal, Reflective particle matrix		
	Host1 prepares one adhesive seal with reflective particle matrix to later seal storage box				
10		Inspector1 asks Host2 and Inspector2 to execute Sealing documentation task (SDT) on not yet applied seal	Camera, Inspection logsheet		
	Host2 executes Sealing documentation task (SDT) on not yet applied seal	Inspector2 executes Sealing documentation task (SDT)			
11	Host1 keeps seal in line of sight of Inspector1	Inspector1 maintains line of sight to seal		Interruption of line of sight	Prepare new adhesive seal and return to step 9
12		Inspector1 asks Inspector2 and Host2 to execute Memory card operating task 1 (MOT-1)[2]	Camera		
	Host2 executes Memory card operating task 1 (MOT-1)	Inspector2 executes Memory card operating task 1 (MOT-1)			

2 *see*: Procedure description: 5) Data transfer procedure

Procedure description: 3) Equipment retrieval and locking procedure — Procedure **3**, page **8**

Step	Hosts	Inspectors	Equipment	Event	Provision to be taken in case of event
13		Inspector1 asks Host2 to put sealing kit (incl. camera) in storage box	Sealing kit		
	Host2 puts sealing kit in storage box				
14		Inspector1 asks Host1 to close and seal storage box and move it into CCTV supervised area	Adhesive seal	Adhesive seal damaged	Recover new adhesive seal from storage box and return to step 9
	Host1 closes storage box, seals it and puts it in CCTV supervised area				
End of ELT					

Appendix: List of materials

- Storage box
- Inspection logsheet
- Sealing kit (Transparent bag, Camera (No. 1), Adhesive seals, Reflective particle matrix)
- Camera (No. 2)
- Inventory list with identification numbers

Procedure description:
4) Visual inspection and photography procedure

Purpose of the procedure

Before the actual SNM dismantlement process the radiation protection area, and more precisely the dismantlement room (DR), has to be inspected visually. The structural conditions (dimensions, openings, pipes ...) have to be confirmed and the DR has to be checked for potential diversion pathways. Deviations from agreed conditions and potential diversion pathways will be documented photographically and in written form. No radiation measurements are undertaken at this point.

The necessary equipment is expected to be already retrieved in advance.

This procedure comprises different tasks: Design verification task (DVT), Diversion pathway search task (PST), General documentation task (GDT)

Location

This procedure takes place in the radiation protection area with main focus on the DR.

Participants

Host1 executing
Host2 supervising
(more Hosts if necessary)
Inspector1
Inspector2

Procedure description: 4) Visual inspection and photography Procedure **4**, page **2**

No.	Action	Hosts	Inspectors	Equipment
I	Verification of structural design	*Host1, Host2 in radiation protection area*	*Inspector1, Inspector2 in radiation protection area*	Building plan of facility Laser distance meter
		Host1 executes Design verification task (DVT)	Inspector1 executes Design verification task (DVT)	
II	Search for potential diversion pathways	*Host1, Host2 in DR*	*Inspector1, Inspector2 in DR*	Inspection logsheet
		Host1 executes Diversion pathway search task (PST)	Inspector1 executes Diversion pathway search task (PST)	
III	Documentation of pathways	*Host1, Host2 in DR*	*Inspector1, Inspector2 in DR*	Camera
		Host1 executes General documentation task (GDT)	Inspector1 executes General documentation task (GDT)	
Repeat actions II and III for every potential diversion pathway				
IV	Validation of intended seal application locations	*Host team leader outside radiation protection area*	*Inspectors outside radiation protection area*	
			Inspectors determine whether potential diversion pathways can/shall be sealed and inform Hosts	
		Host team leader validates their assessment		

List of tasks

Step	Hosts	Inspectors	Equipment	Event	Provision to be taken in case of event
DVT Design verification task					
	Host1, Host2 anywhere in radiation protection area	*Inspector1, Inspector2 anywhere in radiation protection area*			
1		Inspector1 compares structural design with building plan of facility	Building plan of facility	Deviation from building plan	Inspector2 documents deviation AND/OR Dispute settlement procedure
2		Inspector1 compares attachment markings for CCTV cameras with markings in building plan		Deviation from building plan	Inspector2 documents deviation AND/OR Dispute settlement procedure
3 ***(repeat step 3 as needed)***		Inspector1 asks Host1 to measure a specified dimension	Laser distance meter, Tape measure	Deviation from building plan	Inspector2 documents deviation AND/OR Dispute settlement procedure
	Host1 measures indicated distance with distance meter				
4		Inspector1 controls markings of portal monitor measurement areas and asks Hosts1 to measure dimensions	Building plan of facility, Tape measure	Deviation from building plan	Inspector2 documents deviation AND/OR Dispute settlement procedure
	Host1 measures dimensions of portal monitor measurement areas				
End of DVT					

Step	Hosts	Inspectors	Equipment	Event	Provision to be taken in case of event
PST Diversion pathway search task					
	Host1, Host2 in DR	*Inspector1, Inspector2 in DR*			
1		Inspector1 searches room for potential diversion pathways *(such as vents, hatches, cupboards, doors, shafts, windows, drainage, taps)*			
2 ***(if deemed necessary)***		Inspector1 requests searching for potential cavities by letting Host1 knock on wall at specified location		Inspector1 suspects cavity behind wall	Inspector1 asks Inspector2 to note location[1] in Inspection logsheet AND/OR Dispute settlement procedure
	Host1 knocks on wall at specified location				
3		Inspector2 documents potential diversion pathway in Inspection logsheet and Inspector1 performs General documentation task (GDT)	Inspection logsheet		
End of PST					

1 *via reference to room grid for better orientation in DR*

Procedure description: 4) Visual inspection and photography — Procedure **4**, page **5**

Step	Hosts	Inspectors	Equipment	Event	Provision to be taken in case of event
GDT General documentation task[2]					
	Host1, Host2 in DR	*Inspector1, Inspector2 in DR*			
1		Inspector1 asks Host1 to take photo of potential diversion pathway or any appropriate *object*	Camera		
	Host1 takes photo of potential diversion pathway or appropriate *object*				
2	Host1 shows photo to Inspector1		Camera	Photo does not fulfill Inspector1's criteria	Host1 takes another photo OR Dispute settlement procedure
		Inspector1 checks photo to be focused and to show complete potential diversion pathway or *object*			
3		Inspector2 notes time and number of photo	Inspection logsheet		
End of GDT					

2 *This task can be used for general documentation purpose*

Appendix: List of materials

- Clipboard
- Pen
- Building plan of facility
- Laser distance meter
- Tape measure
- Inspection logsheet
- Camera (as part of the sealing kit)
- Step stool

Procedure description: 5) Data transfer procedure

Purpose of the procedure

During the dismantlement process, the camera produces data which will be saved on SD cards. This document describes the necessary actions to remove the data carriers from the cameras and retrieve them from the radiation protection area.

This procedure comprises three different tasks: Memory card operating tasks 1 and 2 (MOT-1/2), Document transfer task (DTT)

Location

This procedure takes place inside the radiation protection area (in the Utility room) and at the controlled boundary to the radiation protection area.

Participants

Inside radiation protection area:
Host1
Host2
Inspector1
Inspector2
At controlled boundary (outside radiation protection area):
Host3
Inspector3
Host4 (radiation protection officer)

No.	Action	Hosts	Inspectors	Equipment
I	Recovery of memory card	*Host1, Host2 in Utility room*	*Inspector1, Inspector2 in Utility room*	Camera Memory Card Secure Vial Gloves
			Inspector1 asks Host1 to execute Memory card operating task 1 (MOT-1)	
		Host1 and Host2 execute Memory card operating task 1 (MOT-1)	Inspector1 and Inspector2 execute Memory card operating task 1 (MOT-1)	
II	Memory card transfer	*Host2 goes to controlled boundary* *Host3 and Host4 outside of controlled boundary*	*Inspector1 goes to controlled boundary* *Inspector3 outside of controlled boundary (in Inspectors' office)*	Secure Vial Memory Card Transparent Gloves Disposable Wipes Handheld Contamination Monitor
			Inspector1 asks Host2 to execute Memory card operating task (MOT-2)	
		Host2 phones Host3 to help in upcoming task and asks Host Team Leader to inform Inspection Team Leader that one Inspector from outside radiation protection is needed		
		Host2 ,Host3 and Host4 execute Memory card operating task (MOT-2)	Inspector1 and Inspector3 execute Memory card operating task (MOT-2)	
III	Document transfer	*Host1 at controlled boundary*	*Inspector2 at controlled boundary*	Inspection Logsheet and further documents Photocopier
		Host1 asks Inspector1 to hand over Inspection logsheet and all further documents		
			Inspector2 hands over all documents to Host1	
		Host1 executes Document transfer task (DTT)		

List of tasks

Step	Hosts	Inspectors	Equipment	Event	Provision to be taken in case of event
MOT-1 Memory card operating task 1					
	Host1, Host2 in Utility room	*Inspector1, Inspector2 in Utility room*			
1		Inspector1 asks Inspector2 and Host1 to execute Equipment retrieval task (ERT)[1] on camera No.2	Camera No.2		
	Host1 executes Equipment retrieval task (ERT) on camera No.2	Inspector2 executes Equipment retrieval task (ERT) on camera No.2			
2		Inspector1 asks Host1, Host2 and Inspector2 to execute Sealing documentation task (SDT) with camera No.2 on seal of camera No.1 (and vice versa, if not already done so)	Camera No.1, Camera No.2, Inspection logsheet		
	Host1 and Host2 execute Sealing documentation task (SDT) with camera No.2 on seal of camera No.1 (and vice versa if not already done so)	Inspector2 executes Sealing documentation task (SDT) with camera No.2 on seal of camera No.1 (and vice versa if not already done so)			
3	Host1 puts on gloves and retrieves empty secure vial		Gloves, Secure vial		
4	Host1 removes memory card from camera No.1 and reads out number of memory card	Inspector2 notes number of memory card	Memory card (from camera No.1)		
	Host1 puts memory card in secure vial		Secure Vial		
	Host1 removes memory card from camera No.2 and reads out number of memory card	Inspector2 notes number of memory card	Memory card (from camera No.2)		
	Host1 puts memory card in secure vial		Secure Vial		
5	Host1 hands over secure vial to Inspector1				
		Inspector1 takes secure vial from Host1			
6	Host1 seals secure vial and asks Inspector2 to note seal number		Sealing kit		
	Host1 verifies noted seal number	Inspector1 notes seal number	Inspection logsheet		

1 *see*: Procedure description: 9) Sealing procedure

7		Inspector1 asks Host1 to retrieve two new memory cards from storage box	2 Memory cards, Inspection logsheet		
	Host1 retrieves two new memory cards from storage box				
		Inspector1 asks Host1 to insert new memory cards into camera No.1 and camera No.2			
	Host1 inserts new memory cards into camera No.1 and camera No.2	Inspector2 notes number of memory cards			
8 ***(if neces-sary)***		Inspector1 asks Host1 to replace camera's battery	Camera No. 1 or 2, Spare battery		
	Host1 replaces old battery with spare battery from utility box and puts old battery in storage box				
9	Host1 verifies that new SD-cards are empty	Inspector1 verifies that new SD-cards are empty			
10		Inspector1 asks Host1 to execute Seal application task (SAT)[2] SD-Card slit of camera No.1 & 2	Sealing kit		
	Inspector1 asks Host1 to execute Seal application task (SAT) SD-card slit of camera No.1 & 2				
		Inspector1 asks Inspector2 and Host1 to execute Sealing documentation task (SDT) camera No.1 & 2	Inspection logsheet		
	Host1 executes Sealing documentation task (SDT) on camera No.1 and camera No.2	Inspector2 executes Sealing documentation task (SDT) on camera No.1 and camera No.2			
11 ***(if camera(s) is(/are) go-ing to be locked)***		Inspector1 asks Inspector2 and Host1 to continue executing Equipment locking task (ELT)[3] on (both) camera(s)			
	Host1 continues executing Equipment locking task (ELT) on (both) camera(s)	Inspector2 continues executing Equipment locking task (ELT) on (both) camera(s)			
End of MOT-1					

2 *see*: Procedure description 9) Sealing procedure
3 *see*: Procedure description 3) Equipment retrieval and locking procedure

Procedure description: 5) Data transfer procedure — Procedure **5**, page **5**

Step	Hosts	Inspectors	Equipment	Event	Provision to be taken in case of event
MOT-2 Memory card operating task 2					
	Host2 inside radiation protection area, Host3 and Host4 at controlled boundary	*Inspector1 inside radiation protection area, Inspector3 at controlled boundary*			
1		Inspector1 transports secure vial with memory cards to controlled boundary	Secure Vial		
2		Inspector1 hands secure vial over to Host2	Secure Vial		
	Host2 takes secure vial and verifies integrity of seal				
3	Host2 breaks seal, removes memory cards from secure vial and places them in centre of inward side of media control zone		Memory card		
4	Host4 scans memory card for contamination		Handheld contamination monitor		
5	Host2 (wearing transparent gloves and having shirt sleeves secured inside) takes disposable wipe to clean memory card		Transparent gloves, Disposable wipes		
6	Host2 shows every disposable wipe to confirm absence of foreign objects within wipe				
		Inspector1 confirms absence of foreign object and grants permission to commence with cleaning			
7	Host2 cleans card with only one wipe at a time and only for one motion		Refuse bin		
	Host2 demonstrates absence of foreign objects before disposing wipe and taking new one				
8	Host2 places memory card in centre of outward side of media control zone				
9	Host3 picks up clean memory card and hands it over to Inspector2			Inspector2 reaches into contaminated side of zone	Inspector2 gets controlled and in case of detection must undergo decontamination immediately
		Inspector2 on outward side of media control zone takes memory card without reaching into contaminated side of zone			
End of MOT-2					

Step	Hosts	Inspectors	Equipment	Event	Provision to be taken in case of event
DTT Document transfer task					
	Host1 outside of radiation protection area				
1	Host1 retrieves documents from designated area after they have been checked for contamination				
2	Host1 checks documents for sensitive information		Inspection logsheet, Documents	Unauthorized information noted in document	Host1 blacks out corresponding passage Dispute settlement procedure
3	Host1 hands back photo copy of reviewed documents to Inspection team		Photocopier		
End of DTT					

Appendix: List of materials

- Sealing kit (including Camera No. 1)
- Camera No. 2
- Memory card
- Secure Vial
- Transparent gloves
- Disposable wipes
- Refuse bin
- Photocopier
- Documents
- Inspection logsheet
- Gloves for the Host
- Handheld contamination monitor

Procedure description: 6) Portal monitor procedure

Purpose of the procedure

This procedure describes the commissioning and decommissioning of the radiation portal monitor as well a function test with small radioactive test sources.
The setup, commissioning, decommissioning and disassembly will be done by a technical staff member of the Host team. The Inspectors are only present to verify the correctness of the process. The functional test should been done after the setup and anytime the Inspectors consider it necessary. Since the display of the laptop that is connected with the portal monitor pillars shows potentially sensitive information, the hosts have to make sure the laptop is closed (at least) during the time where the SNM is near (i.e. the container passage and the dismantlement). The portal monitor then works with a pre-set alarm threshold and alarm lights for neutron and gamma alarm that act as an information barrier.

This procedure comprises different tasks: Portal monitor commissioning task (PCT), Portal monitor functional test task (PFT), Portal monitor decommissioning task (PDT)

Location

This procedure mainly takes place in the hallway, but the portal monitor has to be fetched from the utility room first and brought there again afterwards.

Participants

Host1, a technician of the Host team, guiding the whole process.
Host2, radiation protection supervisor, assisting Host1.
Host3 keeps track of the present inspector(s) and carries sealing kit.
Inspector1 observing the process.
Inspector2 keeping the minutes (inspection logsheet).

Procedure description: 6) Portal monitor procedure — Procedure **6**, page **2**

No.	Action	Hosts	Inspectors	Equipment
I	Transport into hallway	*Host1, Host2 and Host3 in Utility room*	*Inspector1 and Inspector2 in Utility room*	Sealing Kit (Camera) Portal Monitor Box Terminal Laptop
			Inspector1 asks Host1 and Host2 to carry portal monitor box into hallway	
		Host1 and Host2 take portal monitor box and carry it into hallway	Inspector1 observes transport	
II	Setup and commissioning	*Host1, Host2 and Host3 in hallway*	*Inspector1 and Inspector2 in hallway*	Sealing Kit Portal Monitor Box Terminal Laptop
			Inspector1 asks Host1 to execute Portal monitor commissioning task (PCT)	
		Host1 and Host2 execute Portal monitor commissioning task (PCT)		
III	Function test	*Host1, Host2 and Host3 in hallway*	*Inspector1 and Inspector2 in hallway*	Neutron Test Source Gamma Test Source Pair of Tongs
			Inspector1 asks Host1 to execute Portal monitor functional test task (PFT)	
		Host1 and Host2 execute Portal monitor function test task (PFT)		
IV	Disassembly and decommissioning	*Host1, Host2 and Host3 in hallway*	*Inspector1 and Inspector2 in hallway*	Sealing Kit Portal Monitor Portal Monitor Box Terminal Laptop
			Inspector1 asks Host1 and Host2 to execute Portal monitor decommissioning task (PDT)	
		Host1 and Host2 execute Portal monitor decommissioning task (PDT)		

List of tasks

Name	Hosts	Inspectors	Equipment	Event	Provision to be taken in case of event
PCT Portal monitor commissioning task					
	Host1, Host2 and Host3 in hallway	*Inspector1 and Inspector2 in hallway*			
1 ***(repeat for both boxes)***		Inspector1 asks Host3 to perform Sealing documentation task (SDT) on portal monitor box	Portal monitor boxes, Camera		
	Host3 performs Sealing documentation task (SDT)[1] on seals on portal monitor box	Inspector1 and Inspector2 perform Sealing documentation task (SDT)			
2		Inspector1 asks Hosts to carry Portal monitor box and portal monitor equipment box into hallway	Two portal monitor boxes		
	Host1, Host2 and Host3 carry Portal monitor boxes into hallway				
3		Inspector1 asks Host1 to open Portal monitor boxes			
	Host1 breaks seals and opens Portal monitor boxes				
		Inspector1 asks Host1 and Host2 to set up Portal monitor			
4 ***(repeat for both portal monitor pillars)***	Host1 retrieves tripod legs from portal monitor box and screws together tripod	Inspector1 checks integrity of authentication seals	Tripod		
	Host1 attaches feet to tripod and places tripod at marked (agreed) spots	Inspector1 checks correct placement			
5 ***(repeat for both portal monitor***	Host1 and Host2 retrieve detector from Portal monitor box and mount it on tripod	Inspector1 checks integrity of authentication seal	Detector		
	Host1 retrieves battery from Portal monitor box and mounts it on tripod		Battery		

1 *see:* Procedure description: 9) Sealing procedure

Name	Hosts	Inspectors	Equipment	Event	Provision to be taken in case of event
pillars)	Host1 retrieves cable from Portal monitor box and connects battery with detector		Cable		
	Host1 retrieves alarm lights from Portal monitor box and attaches it on top of detector		Alarm lights		
	Host1 retrieves antenna from Portal monitor box and attaches it on top of detector		Antenna		
		Inspector1 checks green power indicating light is on			
6	Host1 retrieves laptop, power cable and laptop antenna and sets it up on desk in hallway	Inspector1 checks integrity of authentication seals	Laptop, Power cable(s), Computer antenna		
	Host1 boots laptop and establishes connection to detector		Laptop		
7		Inspector1 asks Host3 to execute Seal application task (SAT)[2] to connect both tripods to floor	Sealing kit		
	Host3 executes Seal application task (SAT) and seals both tripods to floor				
8		Inspector1 asks Host3 to execute Sealing documentation task (SDT) on applied seals	Sealing kit		
	Host3 executes Sealing documentation task (SDT) on applied seals				
*Check functionality after setup → **Portal monitor functional test task (PFT)***					
END of PCT					

2 *see:* Procedure description: 9) Sealing procedure

Name	Hosts	Inspectors	Equipment	Event	Provision to be taken in case of event
PFT Portal monitor functional test task					
	Host1, Host2 and Host3 in hallway	*Inspector1 and Inspector2 in hallway*			
1		Inspector1 asks Host2 to get test sources	Gamma and neutron test sources		
	Host2 gets neutron and gamma test sources	Inspector1 checks authentication seals			
2		Inspector1 asks Host3 and Inspector2 to execute Sealing documentation task (SDT) on test sources	Camera, Inspection logsheet		
	Host3 executes Sealing documentation task (SDT)[3] on test sources	Inspector2 executes Sealing documentation task (SDT) on test sources			
3 ***(repeat for both portal monitor pillars)***		Inspector1 asks Host2 to hold gamma test source next to portal monitor pillar	Gamma test source, Pair of tongs	No portal monitor gamma alarm	Host1 checks configurations and Host2 repeats step 3 OR Dispute Settlement
	Host2 holds gamma test source next to portal monitor pillar			Portal monitor gamma alarm (red light)	Continue with step 4
4 ***(repeat for both portal monitor pillars)***		Inspector1 asks Host2 to hold neutron test source next to portal monitor pillar	Neutron test source, Pair of tongs	No portal monitor neutron alarm	Dispute Settlement
	Host2 holds neutron test source next to portal monitor pillar			Portal monitor neutron alarm (blue light)	**END of PFT**
END of PFT					

3 *see:* Procedure description: 9) Sealing procedure

Name	Hosts	Inspectors	Equipment	Event	Provision to be taken in case of event
PDT Portal monitor decommissioning task					
	Host1, Host2 and Host3 in hallway	*Inspector1 and Inspector2 in hallway*			
1		Inspector1 asks Host3 to perform Sealing documentation task (SDT) on all seals (including authentication seals) on portal monitor	Camera, Inspection logsheet		
	Host3 performs Sealing documentation task (SDT)[4] on all seals (including authentication seals) on portal monitor	Inspector1 and Inspector2 perform Sealing documentation task (SDT)			
2		Inspector1 asks Host1 and Host2 to decommission portal monitor	Laptop, Laptop antenna		
	Host1 shuts down portal monitor laptop				
	Host1 disconnects laptop antenna and puts it together with laptop and power cable in designated box				
3 ***(repeat for both detector pillars)***	Host1 dismounts antenna and alarm lights on detector and puts them in designated box		Antenna, Cable, Battery, Portal monitor box		
	Host1 unplugs cable from battery and detector and puts it in designated box				
	Host1 dismounts battery and puts it in designated box				
4	Host1 and Host2 dismount detector from tripod and put it in designated box		Detector, Tripod, Portal monitor box		
	Host1 disassembles tripod and puts it in designated box				
5		Inspector1 asks Host3 and Inspector2 to perform Seal application task (SAT) on box(es)	Sealing kit		
	Host3 closes box(es) and performs Seal application task (SAT)	Inspector2 performs Seal application task (SAT)			
6		Inspector1 asks Host3 and Inspector2 to perform Sealing documentation task (SDT)	Camera, Inspection logsheet		
	Host3 performs Sealing documentation task (SAT)	Inspector2 performs Sealing documentation task (SDT)			

4 *see:* Procedure description: 9) Sealing procedure

Name	Hosts	Inspectors	Equipment	Event	Provision to be taken in case of event
7		Inspector1 asks Host1 and Host2 to bring boxes in utility room	Portal monitor boxes		
	Host1 and Host2 carry boxes in utility room				
END of PDT					

Appendix: List of materials

- Sealing kit (transparent bag, adhesive seals, reflective particle matrix, camera)
- Portal monitor in Portal monitor box
- Portal monitor terminal (laptop)
- Portal monitor equipment (antennas, cables, etc.) in Equipment box
- Neutron test source
- Gamma test source
- List with numbers of authentication seals

Procedure description: 7) CCTV procedure

Purpose of the procedure

The NuDiVe exercise will employ the use of closed circuit television cameras (CCTV) as part of the containment and surveillance activities. The CCTV procedures outlined here are used to demonstrate the general benefits that CCTV might offer to an Inspection Team when inspectors cannot be physically present in an area of interest.

The CCTV cameras will stream via a protected connection to the CCTV Terminal computer, which remains sealed while recording the footage. Via another protected connection, a copy is forwarded to the CCTV Host Terminal, which the Host can access at all time to review footage. By default, the CCTV Host Terminal is placed in the Utility Room, but placing it in an adjacent room is possible.

This procedure comprises three different tasks: CCTV commissioning task (CCT), CCTV data recovery task (CRT), CCTV decommissioning task (CDT).

Location

The CCTV will be used to monitor the dismantlement room doorway (Hallway) and the Utility room. Data recovery will be accomplished via access to the CCTV terminal in Utility room (the sole access to the network).

Participants

The Host Team will be responsible for the installation and maintenance of the CCTV system. The Inspection Team will have right to request access to the recorded data. Up to **two hosts** and **two inspectors** are needed to execute the corresponding tasks.

No.	Action	Hosts	Inspectors	Equipment
I	Commissioning of CCTV system	*Host1, Host2 in Utility room*	*Inspector1, Inspector2 in Utility room*	Storage Box CCTV Terminal Computer CCTV Host Terminal Computer CCTV Cameras
			Inspector1 asks Host1 to execute Equipment retrieval task (ERT)[1] for CCTV terminal computer and CCTV cameras	
		Host1 executes Equipment retrieval task (ERT) for CCTV terminal computers and CCTV cameras		
			Inspector1 asks Host1 to execute CCTV commissioning task (CCT)	
		Host1 executes CCTV commissioning task (CCT)		
II	CCTV data recovery	*Host1, Host2 in Utility room*	*Inspector1, Inspector2 in Utility room*	Secure Vial
			Inspector1 asks Host1 to execute CCTV data recovery task (CRT)	
		Host1 executes CCTV data recovery task (CRT)		
		Host1 at controlled boundary	*Inspector1 at controlled boundary*	Disposable Wipes Memory Card(s) Transparent Gloves Secure Vial
			Inspector1 asks Host1 to execute Memory card operating task 2 (MOT-2)[2]	
		Host1 executes Memory card operating task 2 (MOT-2)		
III	Decommissioning of CCTV system	*Host1, Host2 in Hallway*	*Inspector1, Inspector2 in Hallway*	
			Inspector1 asks Host1 to execute CCTV decommissioning task (CDT)	
		Host1 executes CCTV decommissioning task (CDT)		

[1] *see*: Procedure description: 3) Equipment retrieval and locking procedure

[2] see: Procedure description: 5) Data transfer procedure

List of tasks

Step	Hosts	Inspectors	Equipment	Event
CCT: CCTV commissioning task				
	Host1, Host2 in Utility Room	*Inspector1, Inspector2 in Utility Room*		
1		Inspector1 asks Inspector2 and Host2 to execute Sealing documentation task (SDT)[3] on authentication seal of CCTV terminal computer	CCTV terminal computer, Computer cables, Camera, Inspection logsheet	
	Host2 executes Sealing documentation task (SDT)	Inspector2 executes Sealing documentation task (SDT)		
		Inspector1 asks Host1 to set up CCTV terminal in Utility Room		
	Host2 sets up CCTV host terminal in Utility Room, so screen is not visible to planned cameras, and activates it according to CCTV manual			
2		Inspector1 asks Inspector2 and Host2 to execute Sealing documentation task (SDT)[3] on authentication seal(s) of CCTV host terminal	CCTV host terminal computer, Camera, Inspection logsheet	
	Host2 executes Sealing documentation task (SDT)	Inspector2 executes Sealing documentation task (SDT)		
		Inspector1 asks Host1 to set up CCTV host terminal in Utility room		
	Host2 sets up CCTV terminal computer in Utility room and activates it according to CCTV manual			
3 ***(if not already done before)***		Inspector1 asks Host2 and Inspector2 to execute Sealing documentation task (SDT)[3] on authentication seal	Inspection logsheet, Camera	
	Host2 executes Sealing documentation task (SDT) on authentication seal	Inspector2 executes Sealing documentation task (SDT)		
From here on: ***If all inspectors leave utility room, close CCTV terminal and apply seal using Seal application task (SAT) and Sealing documentation task (SDT)***				

[3] *see*: Procedure description: 9) Sealing procedure

4		Inspector1 verifies location of camera mount	Building plan of facility	
5		Inspector1 asks Host1 to attach CCTV camera to camera mount	Camera mount, CCTV camera, CCTV Antenna, Electric cables, *if necessary:* Step stool	
	Host1 attaches CCTV camera to camera mount, attaches antenna and establishes power connection			
6		Inspector1 asks Host2 to execute Seal application task (SAT)[4] to seal CCTV camera and mount	Adhesive seals, Reflective particle matrix	
	Host2 executes Seal application task (SAT) to seal CCTV camera and mount			
		Inspector1 asks Host2 and Inspector2 to execute Sealing documentation task (SDT)	Inspection logsheet, Camera	
	Host2 executes Sealing documentation task (SDT)	Inspector2 executes Sealing documentation task (SDT)		
7		Inspector1 asks Host1 to turn on CCTV system	CCTV terminal	
	Host1 turns on CCTV camera per CCTV manual			
8	Host1 demonstrates that CCTV camera is recording correctly and in right angle	Inspector2 verifies CCTV camera functionality and angle at CCTV terminal in Utility room	CCTV terminal	No recording
Repeat steps 3 to 9 for every agreed CCTV location				
9		Inspector1 asks Host2 to execute Seal application task (SAT) on closed CCTV Terminal, so it cannot be opened without authorisation	Adhesive seals, Reflective particle matrix	
	Host2 executes Seal application task (SAT) on CCTV Terminal			
10		Inspector1 asks Host2 and Inspector2 to execute Sealing documentation task (SDT)	Inspection logsheet, Camera	
	Host2 executes Sealing documentation task (SDT)	Inspector2 executes Sealing documentation task (SDT)		
END of CCT				

4 *see*: Procedure description: 9) Sealing procedure

Step	Hosts	Inspectors	Equipment	Event	Provision to be taken in case of event
CRT: CCTV data recovery task					
	Host1, Host2	*Inspector1, Inspector2*			
1		Inspector1 asks Host1 to execute Equipment retrieval task (ERT)[5] for blank memory card(s)[6] in secure vial			
	Host1 executes Equipment retrieval task (ERT) for blank memory card(s) in secure vial				
2	Host1 reads out number(s) of memory card(s)		Inspection logsheet		
		Inspector1 notes number(s) of memory card(s) in Inspection logsheet			
	Host1 verifies number(s) of memory card(s) noted in Inspection logsheet				
3	Host1 keeps secure vial in line of sight of Inspector2	Inspector2 keeps secure vial in line of sight		Interruption of line of sight	Inspector2 checks seal of secure vial if applicable OR Dispute settlement procedure
4		Inspector1 requests CCTV data from Host1			
	Host1 plugs blank memory card(s) from secure vial into CCTV terminal				
5	Host1 accesses CCTV terminal and saves CCTV data on memory card(s) as specified in CCTV manual			Data is not properly saved to memory card	Dispute settlement procedure
		Inpector1 confirms that CCTV data has been properly saved to memory card(s)			

5 *see*: Procedure description: 3) Equipment retrieval and locking procedure

6 Proceed equivalently for (external) hard drives

Step	Hosts	Inspectors	Equipment	Event	Provision to be taken in case of event
6	Host1 hands secure vial with memory card(s) over to Inspector1		Secure vial		
		Inspector1 takes secure vial with memory card(s)			
7	Host1 seals secure vial and asks Inspector2 to note seal number		Adhesive seal, Inspection logsheet		
		Inspector2 notes seal number			
	Host1 verifies seal number in Inspection logsheet				
END of CRT					

Step	Hosts	Inspectors	Equipment	Event
CDT: CCTV decommissioning task				
	Host1, Host2	*Inspector1, Inspector2*		
1		Inspector1 checks number and integrity of seal on CCTV camera and camera mount	Inspection logsheet, Camera, *if necessary:* Step stool	
		Inspector1 asks Host2 and Inspector2 to execute Sealing documentation task (SDT)[7] on seal		
	Host2 executes Sealing documentation task (SDT)	Inspector2 executes Sealing documentation task (SDT)		
2		Inspector1 asks Host1 to detach CCTV camera from camera mount	CCTV camera mount, CCTV camera, *if necessary:* Step stool	
	Host1 detaches CCTV camera from camera mount			
3		Inspector1 asks Host2 and Inspecor2 to execute Sealing documentation task (SDT) on CCTV camera's authentication seal	CCTV camera, Inspection logsheet	
	Host2 executes Sealing documentation task (SDT) on CCTV camera's authentication seal	Inspector2 executes Sealing documentation task (SDT) on CCTV camera's authentication seal		
4		Inspector1 asks Host2 to execute Equipment locking task (ELT)[8] on CCTV camera	CCTV camera	
	Host2 executes Equipment locking task (ELT) on CCTV camera			
Repeat steps 1 to 4 for every CCTV camera				
5		Inspector1 asks Host1 to shut down CCTV terminals	CCTV terminal computer, CCTV host terminal computer	
	Host1 shuts down CCTV terminal and CCTV host terminal as described in CCTV manual			

[7] *see*: Procedure description: 9) Sealing procedure

[8] *see:* Procedure description: 3) Equipment retrieval and locking procedure

Step	Hosts	Inspectors	Equipment	Event
6		Inspector1 asks asks Host2 and Inspector2 to execute Sealing documentation task (SDT) on CCTV terminal and CCTV host terminal	Inspection logsheet, Camera	
	Host2 executes Sealing documentation task (SDT)	Inspector2 executes Sealing documentation task (SDT)		
7		Inspector1 asks Host2 to decommission CCTV terminal and CCTV host terminal and to execute Equipment locking task (ELT)[9] on it	Camera, Seals, CCTV terminal computer, CCTV host terminal computer	
	Host2 decommissions CCTV terminals and executes Equipment locking task (ELT) on them			
END of CDT				

9 *see*: Procedure description: 3) Equipment retrieval and locking procedure

Appendix: List of materials

- Inspection logsheet
- Building plan of facility
- CCTV camera mount and installation materials
- *if necessary:* step stool
- CCTV cameras
- CCTV camera antennas
- CCTV camera cables and extension cables
- Blank memory cards in storage box
- 2 CCTV terminal computers (Laptops) for viewing CCTV footage

Procedure description:

8a) Handheld neutron sweeping procedure

Purpose of the procedure

This procedure describes the sweeping scan of the Dismantlement Room (DR)[1] with a handheld neutron detector to ensure the absence of undeclared neutron sources. It describes the procedure for one Inspector-Host pair handling one device. The neutron sweeping can be done parallel to the gamma sweeping measurement.
As a confidence interval for the alarm threshold, 2 sigma has been chosen so as not to exaggerate type II errors, i.e. to avoid not detecting a present source. The device automatically calculates the alarm threshold from the result of the background measurement. To prevent the tampering of the neutron background level, the background measurement has to be compared to a background measurement outside the room.
For a detailed description of the detector's operation and functionality refer to the *Neutron Search Detector KSAR1U.06 Operating Manual*.

This procedure comprises three different tasks: Preparatory background measurement task (PBT), Background measurement task (BMT), Neutron sweep task (NST)

Location

This procedure takes place in the Hallway and the Dismantlement Room (DR), before the NED enters or after it left the room.

Participants

Host1 operating the neutron search detector.
Host2 watching the Inspectors.
Inspector1 supervising Host1.
Inspector2 keeping the minutes (inspection logsheet).

1 *this procedure is also applicable to other rooms inside the radiation protection area*

No.	Action	Hosts	Inspectors	Equipment
I	Preparatory measures	*Host1 and Host2 in Utility room*	*Inspector1 and Inspector2 in Utility room*	Handheld Neutron Detector Pen Inspection Logsheet
			If not already done: Inspector1 asks Host1 to get neutron detector	
		If not already done: Host1 gets neutron detector according to Equipment retrieval task (ERT)[2]		
			Inspector1 asks Host1 to execute Preparatory background measurement task (PBT)	
		Host1 executes Preparatory background measurement task (PBT)		
			Inspector1 asks Host1 to enter DR	
		Host1 enters DR with detector still running to keep measured background value in its memory	Inspector1 enters DR	
II	Neutron background measurement inside DR	*Host1 and Host2 in DR*	*Inspector1 and Inspector2 in DR*	Handheld Neutron Detector Pen Inspection Logsheet
			Inspector1 asks Host1 to execute Background measurement task (BMT)	
		Host1 executes Background measurement task (BMT)		
III	Scanning room for neutron sources	*Host1 and Host2 in DR*	*Inspector1 and Inspector2 in DR*	Handheld Neutron Detector Pen Inspection Logsheet
			Inspector1 asks Host1 to execute Neutron sweep task (NST)	
		Host1 executes Neutron sweep task (NST)		

2 *see:* Procedure description: 3) Equipment retrieval and locking procedure

List of tasks

Step	Hosts	Inspectors	Equipment	Event	Provision to be taken in case of event
PBT Preparatory background measurement task					
	Host1 and Host2 in Utility room	*Inspector1 and Inspector2 in Utility room*			
1		Inspector1 chooses spot in centre of hallway or Utility room and asks Host1 to go there	Neutron detector		
	Host1 moves to spot and places detector in a way Inspector1 has clear view of display				
2		Inspector1 asks Host1 to switch on detector	Neutron detector		
	Host1 starts neutron detector by pressing “power on/off” button for 5 s. Device will start warm-up process (~60 s), followed by background count rate measurement over 300 s				
3	Host2 notes measurement result	Inspector1 reads out and Inspector2 writes down result of background measurement and place it was measured at	Pen, Inspection logsheet	Value lower than 0.3 cps	Don’t turn off detector! **End of PBT**
				Value higher than 0.3 cps	Continue with step 4
4 ***(if value is higher than 0.3 cps)***		Inspector1 asks Host1 to repeat background measurement at two other spots	Neutron detector, Pen, Inspection logsheet	Values vary by order of magnitude	Dispute Settlement Procedure
	Host1 repeats background measurement at indicated spots via “retake background” option in device’s Setup Menu	Inspector1 reads out and Inspector2 notes results and places of measurements			
5 ***(if value is higher than 0.3 cps)***		Inspector1 asks Host1 to set median result of the three measurements as reference for background measurement inside DR			
	Host1 keeps median result in detector (if it was result of last measurement) or retakes background at spot where median result was measured at (Do NOT turn off device after that![3])				
END of PBT					

3 *Switching off will erase all data on the device including the measured background value that is needed in the following step*

Step	Hosts	Inspectors	Equipment	Event	Provision to be taken in case of event
BMT Background measurement task					
	Host1 and Host2 in DR	*Inspector1 and Inspector2 in DR*			
1		Inspector1 chooses spot in centre of DR and asks Host1 to execute integrated measurement over 30 s there	Neutron detector, Pen, Inspection logsheet	Display shows “N > B”, i.e. measured count rate is 2 sigma over background	See step 2
	Host1 places detector at indicated spot, selects INTEGRAL mode and executes integrated measurement over 30 s (to compare with preparatory background measurement)	Inspector1 reads out and Inspector2 writes down measurement result and place it was taken at		Display shows “N ≤ B”	Continue with step 3
2 ***(if display shows “N>B”)***		Inspector1 asks Host1 to repeat measurement twice at same spot	Neutron detector, Pen, Inspection logsheet	Display shows “N > B” in 2^{nd} or 3^{rd} measurement	Dispute Settlement procedure
	Host1 repeats integrated measurement over 30 s twice at same spot as before	Inspector2 writes down measurement results		Display shows “N ≤ B” in both measurements	Continue with step 3
3		Inspector1 asks Host1 to take new background measurement in DR	Neutron detector		
	Host1 takes new background measurement in DR that defines threshold for coming sweeping process				
END of BMT					

Step	Hosts	Inspectors	Equipment	Event	Provision to be taken in case of event
NST Neutron sweep task					
	Host1 and Host2 in DR	*Inspector1 and Inspector2 in DR*			
1		Inspector1 indicates spot and direction and asks Host1 to start measurement in SEARCH mode	Neutron detector	Relevant rise of count rate occurs *(Inspector1 decides if rise of count rate is relevant)*	See step 2
	Host1 selects SEARCH mode and starts measuring from indicated spot on by moving detector slowly near surface in instructed direction *(Inspector1 decides if pace is reasonable or if measurement has to be repeated in slower pace)*			No relevant rise of count rate is noticeable	See step 3
2 ***(if relevant rise of count rate occurs)***		Inspector1 asks Host1 to perform integrated measurement (INTEGRAL mode) at suspicious spot	Neutron detector, Pen, Inspection logsheet	Value does not exceed threshold (2 sigma)	Continue with step 3
	Host1 selects INTEGRAL mode and executes integrated measurement at suspicious spot for 30 s	Inspector2 notes spot and measurement result		High count rate occurs again	Dispute settlement procedure
3 ***(if no relevant rise of count rate is noticeable)***		Inspector1 proceeds by instructing Host1 on how to sweep rest of room bit by bit	Neutron detector	Relevant rise of count rate occurs *(Inspector1 decides if rise of count rate is relevant)*	See step 2
	Host1 continues to sweep rest of room as instructed by Inspector1			No relevant rise of count rate is noticeable	Continue step 3
END of NST					

Appendix: List of materials

- Neutron search detector
- Pen
- Clipboard
- Inspection logsheet
- Step stool

Procedure description:

8b) Handheld gamma sweeping procedure

Purpose of the procedure

This procedure describes the sweeping scan of the Dismantlement Room (DR)[1] with a handheld gamma detector to ensure the absence of undeclared gamma sources. It describes the procedure for one Inspector-Host pair handling one device. The gamma sweeping scan can be done parallel to the neutron sweeping scan.
There are two modes of operation: The FINDER mode for the sweeping scan itself and the DOSE rate mode as an extra measurement in case something suspicious comes up during the sweeping scan. In the FINDER mode a radioactive source should be visually noticeable by a rise of the count rate in the graph on the display. Additionally as help for the inspector an alarm sound goes off when values exceed 2 sigma of the background count rate. In the DOSE rate mode the absolute alarm threshold is chosen so that 50 g of plutonium with little shielding should be detectable.
For a more detailed description of the detector's operation and functionality, refer to the operating manual.

This procedure comprises the following task: Gamma sweep task (GST)

Location

This procedure takes place in the Dismantlement Room (DR), before the NED enters or after it left the room.

Participants

Host1 operating the handheld gamma detector.
Host2 watching the Inspectors.
Inspector1 supervising Host1.
Inspector2 keeping the minutes (inspection logsheet).

1 *this procedure is also applicable to other rooms inside the radiation protection area*

No.	Action	Hosts	Inspectors	Equipment
I	Gamma sweeping scan of room	*Host1 and Host2 in DR*	*Inspector1 and Inspector2 in DR*	Handheld Gamma Detector Pen Inspection Logsheet
			If not already done: Inspector1 asks Host1 to get gamma detector	
		If not already done: Host1 gets gamma detector according to Equipment retrieval task (ERT)[2]		
			Inspector1 asks Host1 to execute Gamma sweep task (GST)	
		Host1 executes Gamma sweep task (GST)		

2 *see:* Procedure description: 3) Equipment retrieval and locking procedure

List of tasks

Step	Hosts	Inspectors	Equipment	Event	Provision to be taken in case of event
GST Gamma sweep task					
	Host1 and Host2 in DR	*Inspector1 and Inspector2 in DR*			
1		Inspector1 chooses spot in centre of DR and asks Host1 to go there	Gamma detector		
	Host1 moves to spot and holds detector in a way Inspector1 has clear view of display				
2		Inspector1 asks Host1 to switch on detector and to change to FINDER mode	Gamma detector		
	Host1 starts detector and selects FINDER mode				
3		Inspector1 indicates spot and direction	Gamma detector, Pen, Inspection logsheet	No relevant rise of dose rate is noticeable	See step 5
	Host1 starts measuring from indicated spot on by moving detector slowly near surface in instructed direction *(Inspector1 decides if pace is reasonable or if measurement has to be repeated in slower pace)*			Relevant rise of dose rate occurs *(Inspector1 decides if rise of dose rate is relevant)*	See step 4
4 ***(if relevant rise of dose rate occurs)***		Inspector1 asks Host1 to perform measurement in DOSE rate mode at suspicious spot	Gamma detector	Value does not exceed alarm threshold	Continue with step 5
	Host1 selects DOSE rate mode and executes measurement at suspicious spot for ~30 s			High dose rate occurs again	Dispute settlement procedure
5 ***(if no relevant rise of dose rate is noticeable)***		Inspector1 proceeds by instructing Host1 on how to sweep rest of room bit by bit	Gamma detector	No relevant rise of dose rate is noticeable	Continue step 5
	Host1 continues to sweep rest of room as instructed by Inspector1			Relevant rise of dose rate occurs *(Inspector1 decides if rise of dose rate is relevant)*	See step 4
END of GST					

Appendix: List of materials

- Handheld gamma detector
- Pen
- Clipboard
- Inspection logsheet
- Step stool

Procedure description: 9) Sealing procedure

Purpose of the procedure

During the dismantlement process, the radiation protection area has to be checked for potential diversion pathways which have to be sealed before the actual dismantlement takes place. This document describes the actions to execute the sealing of the interior of the dismantlement room (DR). Seal application and sealing documentation is also needed on other occasions, e.g. opening and closing the equipment box.

This procedure comprises different tasks: Seal application task (SAT), Sealing documentation task (SDT).

Location

This procedure can take place anywhere in the radiation protection area. However, focus clearly lies on the DR.

Participants

Host1 applying seals.
Host2 handling the camera and carrying the sealing kit.
Inspector1 giving instructions.
Inspector2 keeping the minutes (inspection logsheet).

No.	Action	Hosts	Inspectors	Equipment
I	Application of adhesive seals and reflective particle matrix	*Host1, Host2*	*Inspector1, Inspector2*	Adhesive Seals Reflective Particle Matrix Camera
			Inspector1 asks Host1 to execute Seal application task (SAT) at chosen location	
		Host1 executes Seal application task (SAT) at location chosen by Inspector1		
II	Documentation of sealing	*Host1, Host2*	*Inspector1, Inspector2*	Camera Inspection Logsheet
			Inspector1 asks Host2 and Inspector2 to execute Sealing documentation task (SDT)	
		Host2 executes Sealing documentation task (SDT)	Inspector2 executes Sealing documentation task (SDT)	
			If required: Inspector1 asks Host2 and Inspector2 to execute Memory card operating task 1 & 2 (MOT-1&2)[1]	
		If required: Host2 executes Memory card operating task 1 & 2 (MOT-1&2)	*If required:* Inspector2 executes Memory Card operating task 1 & 2 (MOT-1&2)	
Repeat actions I and II for every seal				

1 *see:* Procedure description: 5) Data transfer procedure

List of tasks

Step	Hosts	Inspectors	Equipment	Event	Provision to be taken in case of event
SAT Seal application task					
	Host1 applying seal, Host2 carrying sealing kit	*Inspector1 giving instructions, Inspector2 maintains overview*			
1		Inspector1 indicates location where Host1 ought to apply seal	Adhesive seals	Adhesive seal damaged	Use another adhesive seal and repeat step 1
	If surface is dusty: Host1 dusts off surface	*If surface is dusty:* Inspector1 asks Host1 to clean surface			
	Host1 takes one adhesive seal from Host2 and applies it to indicated location *NB : no tampering occurs, bar code is completely readable and not distorted*				
2		Inspector1 asks Host1 to apply reflective particle matrix	Reflective particle matrix	Reflective particle matrix on bar code	Use another adhesive seal and return to step 1
	Host1 takes reflective particle matrix from Host2 and applies it on right half of adhesive seal			Reflective particle matrix inadequate	Reapply reflective particle matrix OR Use new seal (step 1)
3	Host1 hands reflective particle matrix back to Host2 who keeps camera and seals in line of sight of Inspector2		Camera	Interruption of line of sight	Inspector2 checks identification number of camera OR Dispute settlement procedure
		Inspector2 keeps camera and seals within line of sight			
Proceed with Sealing documentation task (SDT)					
End of SAT					

Step	Hosts	Inspectors	Equipment	Event	Provision to be taken in case of event
SDT Sealing documentation task					
	Host1 reading seal numbers, Host2 handling camera	*Inspector1 giving instructions, Inspector2 writing inspection logsheet*			
1		Inspector1 asks Host1 to read out seal number and Inspector2 to fill out inspection logsheet	Inspection logsheet		
	Host1 reads out seal number				
		Inspector2 notes seal number			
	Host1 checks noted seal number				
2		Inspector1 asks Host2 to take photo of seal's complete bar code and reflective particle matrix	Camera	Bar code and reflective particle matrix can not be capture both in one photo	See step 3
	Host2 takes photo of seal's complete bar code and reflective particle matrix in approx. 30 cm distance rectangular to surface				
3 ***(if bar code and reflective particle matrix can not be captured in one photo)***		Inspector1 asks Host2 to take two separate photos			
	Host2 takes photo of complete bar code and captures reflective particle matrix with seal number readable separately				
4	Host2 shows photo(s) to Inspector1		Camera	Photo does not fulfill Inspector1's criteria	Return to step 2 OR Dispute settlement procedure
		Inspector1 checks photo(s) to be focused and to show complete seal including bar code and reflective particle matrix			
End of SDT					

Appendix: List of materials

- Clipboard
- Pen
- Inspection logsheet
- Sealing kit (Camera, Adhesive Seals, Reflective particle matrix, Transparent bag)

Procedure description: 10) Container movement procedure

Purpose of the procedure

This procedure describes the movement of containers through the portal monitor measurement area.
Before and after the dismantlement process all containers have to be checked for radiation to assure that only the ones that are designated as such contain SNM. To enable an undisturbed sweeping scan, the containers containing radioactive material must be absent during the first sweeping scan and need to leave the DR again before the final sweeping. Therefor they are going to pass the portal monitors twice where they are checked for radiation.

Remark: While the inspectors are not allowed to witness any movement of the containers that includes lifting they are allowed to watch the containers being moved horizontally. Hence the container has to be ready for transport at the beginning of this procedure. All preparations such as lifting the container onto a transporting device has to be done in advance by the host personnel in absence of inspectors and is not part of this procedure.

When the SNM is near the portal monitor the portal monitor laptop could show potentially sensitive measurement data. Thus the hosts have to make sure that the laptop is closed (at least) during the time where the container is close by (< 30 m). During that time the portal monitor uses only the alarm lamps as alarm indicators functioning as an information barrier.

This procedure comprises two tasks: Container entrance task (CET-1), Container exit task (CET-2).

Location

This procedure takes place in front of the Dismantlement Room (DR) where the radiation portal monitors are set up.

Participants

Host1 as the leading host.
Host2 moving the container inside the portal monitor secured area.
Host3 moving the container outside the portal monitor secured area.
Host4 carrying sealing kit and operating the camera.
Inspector1 to witness the movement.
Inspector2 to assist with the sealing documentation.

Procedure description: 10) Container movement procedure — Procedure **10**, page **2**

No.	Action	Hosts	Inspectors	Equipment
I	Container entering dismantlement room	*Host1, Host2, Host3 and Host4 outside DR*	*Inspector1 and Inspector2 in hallway (one at each portal monitor pillar)*	Container Transporting Device Portal Monitor Inspection Logsheet Pen
		Host1 informs Inspector1 about intention to move one (or more) container(s) into DR		
		Host1 makes sure laptop of portal monitor is closed before container enters hallway		
		Host1, Host2, Host3 and Host4 execute Container entrance task (CET-1)	Inspector1 and Inspector2 execute Container entrance task (CET-1)	
Repeat CET-1 for every container entering DR				
II	Container leaving dismantlement room	*Host1 and Host2 inside DR, Host3 and Host4 in hallway*	*Inspector1 and Inspector2 in hallway (one at each portal monitor pillar)*	Container Transporting Device Portal Monitor Inspection Logsheet Pen
		Host1 requests to move one (or more) container(s) out of DR		
		Host4 enters DR	Inspector1 and Inspector2 enter DR	
		Host4 executes Seal application task (SAT)[1] on container(s)	Inspector2 executes Seal application task (SAT) on container(s)	
		Host4 executes Sealing documentation task (SDT)	Inspector2 executes Sealing documentation task (SDT)	
		Host4 leaves DR	Inspector1 and Inspector2 leave DR	
		Host1, Host2 and Host3 execute Container exit task (CET-2) for each container	Inspector1 and Inspector2 execute Container exit task (CET-2) for each container	
Repeat CET-2 for every container leaving DR				

1 *see*: Procedure description: 9) Sealing procedure

List of tasks

Step	Hosts	Inspectors	Equipment	Event	Provision to be taken in case of event
CET-1 Container entrance task					
	Host1, Host2, Host3 and Host4 outside portal monitor secured area	*Inspector1, Inspector2 outside portal monitor secured area*			
1 ***(before container enters hallway)***	Host1 steps into portal monitor's measurement area and waits until measurement is completed (20 s)		Portal monitor	No alarm within 20 s	Host1 exits measurement area and waits in front of DR
				Portal monitor alarms	Dispute settlement procedure
2 ***(before container enters hallway)***	Host2 steps into measurement area and waits until measurement is completed (20 s)		Portal monitor	No alarm within 20 s	Host2 exits measurement area and waits in front of DR
				Portal monitor alarms	Dispute settlement procedure
3	Host3 brings container into hallway		Pen, Inspection logsheet		
		Inspector2 logsheets time and container's ID and checks integrity of seals			
4		Inspector1 asks Host4 and Inspector2 to execute Sealing documentation task (SDT)	Pen, Inspection logsheet, Camera		
	Host4 executes Sealing documentation task (SDT)[2]	Inspector2 executes Sealing documentation task (SDT)			
5	Host3 moves container into portal monitor area		Container, Transporting device	Container larger than measurement area	Reposition container after measurement and repeat step 5 & 6 until complete container has been measured
		Inspector1 checks positioning of container			

2 *see*: Procedure description: 9) Sealing procedure

Step	Hosts	Inspectors	Equipment	Event	Provision to be taken in case of event
CET-1 Container entrance task					
6	Host3 steps back and waits in a distance of >1 m from portal monitor until measurement is completed (20 s)		Portal monitor	No alarm within 20 s	*For TAI-container:* Dispute settlement *For empty container:* Continue with step 7
				Portal monitor alarms	*For TAI-container:* Continue with step 7 *For empty container:* Dispute settlement
7	Host1 opens door to DR and Host2 moves container into DR		Container		
End of CET-1					

Step	Hosts	Inspectors	Equipment	Event	Provision to be taken in case of event
CET-2 Container exit task					
	Host1 and Host2 inside DR, *Host3 and Host4 outside portal monitor secured area (in hallway)*	*Inspector1 and Inspector2 outside portal monitor secured area (in hallway)*			
1	Host1 opens door of DR and Host2 pushes container through open door into portal monitor area		Container, Transporting device	Container larger than measurement area	Reposition container after measurement and repeat until complete container has been measured
		Inspector1 checks positioning of container			
2	Host2 steps back and waits in a distance of >1 m from portal monitor until measurement is completed (20 s)		Portal monitor	No alarm within 20 s	*For SNM-container:* Dispute settlement *For non-SNM-container:* Continue with step 3
				Portal monitor alarms	*For SNM-container:* Continue with step 3 *For non-SNM-container:* Dispute settlement
3	Host3 moves container out of measurement area into hallway		Pen, Inspection logsheet		
		Inspector1 does visual check on container and notes time and container's ID number			
End of CET-2					

Appendix: List of materials

- Portal monitor
- Container(s)
- Transporting device(s)
- Inspection logsheet
- Pen
- Sealing kit (Transparent bag, Camera, Adhesive seals, Reflective particle matrix)

Procedure description: 11) Host DR Exit/Entry procedure

Purpose of the procedure

During the actual dismantlement process a host might enter or leave the DR. This document describes the actions to execute the movement of host personnel into or out of the DR. The alarm threshold of the portal monitor is chosen to detect an amount of 50 gram of weapon-grade plutonium with little shielding inside the measurement area.

In case something is detected by the radiation portal monitor the handheld neutron and gamma detectors should be at hand to perform a body scan on the suspicious person. It is therefore advisable to keep them within reach during the dismantlement process, so not much time is wasted by retrieving them from the storage box in case of need. As the neutron detector also takes a lot of time for initial background measurements it should be already turned on.

This procedure comprises two tasks: Outward transfer task (OTT), Inward transfer task (ITT).

Location

This procedure takes place in the hallway outside the Dismantlement room (DR).

Participants

Host1 to leave the DR.
Host2 to enter the DR.
Host3 and **Host4** in the hallway, outside the portal monitor secured area.
Two Inspectors to supervise the procedure, in the hallway, staying in the agreed places.

Procedure description: 11) Host DR Exit/Entry procedure — Procedure **11**, page **2**

No.	Action	Hosts	Inspectors	Equipment
I	Outward transfer of host personnel	*Host1 in DR, Host3 and Host4 in Hallway*	*Inspector1 and Inspector2 in Hallway*	Portal Monitor Gamma Detector Neutron Detector Fixed Telephone
		Host1 signals Host3 about intention to leave DR		
		Host3 informs Inspector1		
			Inspector1 asks Host3 and Host4 to execute Outward transfer task (OTT)	
		Host3, Host4 and Host1 execute Outward transfer task (OTT)	Inspector1 and Inspector2 observe portal monitor from agreed place, while having no visual access to interior of DR	
II	Inward transfer of host personnel	*Host2, Host3 and Host4 in Hallway*	*Inspector1 and Inspector2 in Hallway*	Portal Monitor Gamma Detector Neutron Detector Fixed Telephone
		Host2 informs Inspector1 about intention to enter DR		
			Inspector1 asks Host2, Host3 and Host4 to execute Inward transfer task (ITT)	
		Host2, Host3 and Host4 execute Inward transfer task (ITT)	Inspector1 and Inspector2 observe portal monitor from agreed place, while having no visual access to interior of DR	

List of tasks

Step	Hosts	Inspectors	Equipment	Event	Provision to be taken in case of event
OTT Outward transfer task					
	Host1 in DR, Host3 and Host4 in Hallway	*Inspector1 and Inspector2 in Hallway*			
1	Host3 makes sure present Inspectors are positioned in agreed place and have no visual access to DR				
		Inspector1 and Inspector2 stay in agreed place during outward transfer			
2	Host3 signals Host1 in DR		Fixed telephone		
3	Host1 opens door, steps out of DR				
4		Inspector1 asks Host1 to step into portal monitor area and to stay in its centre for 20 s	Portal monitor	No alarm within 20 s	See step 5
	Host1 step into marked portal monitor area stays in its centre of until new instructions come up			Portal monitor alarms continuously	See step 6
5 ***(if no alarm within 20 s)***		Inspector1 asks Host1 to leave portal monitor area		**END of OTT**	
	Host1 steps out of portal monitor area				
6 ***(if portal monitor raises an alarm continuously)***		Inspector1 asks Host1 to step out of portal monitor area			
	Host1 steps out of portal monitor area				
7		Inspector1 asks Host3 to perform body scan on Host1 with handheld gamma detector	Handheld gamma detector	No alarm	See step 8
	Host3 scans Host1 with handheld gamma detector from top to bottom in slow pace including shoes from below. Host3 performs measurement both on front and on backside of Host1	Inspector1 observes measurement		Alarm	Dispute settlement procedure, See step 9

Procedure description: 11) Host DR Exit/Entry procedure — Procedure **11**, page **4**

Step	Hosts	Inspectors	Equipment	Event	Provision to be taken in case of event
8		Inspector1 asks Host3 to perform body scan on Host1 with handheld neutron detector in SEARCH mode	Handheld neutron detector	No alarm	Repeat portal monitor measurement (steps 3 and 4)
	Host3 scans Host1 with handheld neutron detector from top to bottom in slow pace including shoes from below. Host3 performs measurement both on front and on backside of Host1	Inspector1 observes measurement		Alarm	See step 9
9 ***(if handheld detector raises an alarm)***		Inspector1 asks Host3 to inform Inspection team leader and asks Host1 to stay in measurement area	Fixed telephone		
	Host3 signals Hosts in DR and informs both team leaders				
10	Host team leader executes *Dispute settlement procedure*	Inspection team leader executes *Dispute settlement procedure*			
END of OTT					

Step	Hosts	Inspectors	Equipment	Event	Provision to be taken in case of event
ITT Inward transfer task					
	Host2, Host3 and Host4 in hallway outside of portal monitor secured area	*Inspector1 and Inspector2 in hallway outside of portal monitor secured area*			
1	Host3 makes sure present Inspectors are positioned in agreed place and have no visual access to DR				
		Inspector1 and Inspector2 stays in agreed place during inward transfer			
2		Inspector1 asks Host2 to step into portal monitor area	Portal monitor		
	Host2 steps into portal monitor area				
3		Inspector1 asks Host2 to stay in centre of portal monitor area for 20 s	Portal monitor	No alarm within 20 s	See step 4
	Host2 stays in centre of portal monitor area for 20 s			Portal monitor alarms continuously	See step 5
4 ***(if no alarm within 20 s)***	Host3 signals Hosts in DR		Fixed telephone		
	Hosts inside DR open door				
	Host2 steps in DR and closes door			**END of ITT**	
5 ***(If portal monitor raises an alarm continuously)***		Inspector1 asks Host2 to step out of portal monitor area			
	Host2 steps out of portal monitor area				
6		Inspector1 asks Host3 to perform body scan on Host2 with handheld gamma detector	Handheld gamma detector	No alarm	See step 7
	Host3 scans Host2 with handheld gamma detector from top to bottom in slow pace including shoes from below. Host3 performs measurement both on front and on backside of Host1	Inspector1 observes measurement		Alarm	Dispute settlement procedure, See step 8

Procedure description: 11) Host DR Exit/Entry procedure — Procedure **11**, page **6**

Step	Hosts	Inspectors	Equipment	Event	Provision to be taken in case of event
7		Inspector1 asks Host3 to perform body scan on Host2 with handheld neutron detector in SEARCH mode	Handheld gamma detector	No alarm	Repeat portal monitor measurement (steps 2 and 3)
	Host3 scans Host2 with handheld neutron detector from top to bottom in slow pace including shoes from below. Host3 performs measurement both on front and on backside of Host1	Inspector1 observes the measurement		Alarm	See step 8
8 ***(if handheld detector raises an alarm)***		Inspector1 asks Host3 to inform Inspection team leader and asks Host2 to stay in same place	Fixed telephone		
	Host3 informs both team leaders				
9	Host team leader executes *Dispute settlement procedure*	Inspection team leader executes *Dispute settlement procedure*			
END of ITT					

Appendix: List of materials

- Clipboard
- Pen
- Inspection logsheet
- Portal monitor
- Neutron detector
- Gamma detector
- Fixed telephone

C. Participants

C.1. Required skills

NuDiVe exercice – Background paper on skills needed for participants

Inspired from IPNDV phase I final report / WG2 deliverable : "Part IV. Verification Entity - Chapter 17. Composition of Inspection Team: Inspector Functions, Tasks, and Skills"

The NuDiVe exercise focuses on the technologies and procedures providing sufficient confidence about the absence of diversion of nuclear materials during the dismantlement operation of a nuclear warhead within a treaty-related disarmament regime. The aim of the exercise is to **assess how the chain of custody can be maintained during and after the dismantlement step in a way that strengthens the confidence and effectiveness of a nuclear disarmament verification regime**.

The exercise is part of Step 8 of the IPNDV Dismantlement Process and will focus on a step 8.2 that excludes manipulation of HE and therefore the need of a pyrotechnical adapted building. It will be assumed that the separation of HE from the TAI (Treaty Accountable Item) would have occurred directly before the exercise, in a step 8.1.

T**he skills for participants listed below are focused on the specific case of the NuDiVe exercise**, regardless of other skills that may be needed in a broader nuclear disarmament regime context, and are necessarily narrower than previous work done within the IPNDV.

1. Inspector team skills

Inspectors for the NuDiVe exercise will be organized into a self-supporting inspection team. Team members and subgroups should be able to complete different tasks based on the team members' expertise:

1. ensure the chain of custody of the SNM container;
2. confirm that the SNM container meets the agreed characteristics ;
3. confirm with sufficient assurance the non-diversion of materials during dismantlement operations;
4. ensure the respect of the host country regulations.

For these tasks to be fulfilled, skills within the team's participants could include:

- **"Inspection-related skills",** including non-technical **"soft skills"**;
- **"Technical skills"**.

1.1. *Inspection-related skills*

Inspection specialists would need to have nuclear weapons-related, or similar inspection experience and knowledge. Other skills may be helpful to conduct support activities for the inspection team.

Core skills:

- **Administrative procedures** related to the verification regime (i.e., POE/POE exit procedures, setting-up an Inspector Station, etc.);

1

- Previous **experience with other arms control inspection regimes**—nuclear inspection experience is desired but not necessary so long as the individual can prove they have the necessary skills and knowledge to support the work of the team;
- The ability to **ensure that chain of custody and physical security procedures** are followed.
- **Negotiation skills**; and
- **Report-writing** skills based on factual findings.

Other possible skills may include:

- Team management skills ;
- Confidentiality and security procedures, including team security and boundary control;
- Logistics support required to support the team during the course of inspections;
- Supporting the health and safety of the inspection team, including radiation protection;
- Diplomatic or legal experience who could be helpful in resolving disagreements during inspection activities;
- Military or other deployed operational experience that enables them to help others operate in an unfamiliar environment; and
- Professionals with backgrounds in facility design or operation, not only for NEDs but also for any other military or nuclear processing activities;

An inspection team leader, preferably chosen among those inspection specialists would be a senior inspector, with nuclear weapons-related or similar inspection experience.

1.2. Technical skills

Technical specialists would be experts with specific knowledge, experience and hands-on skills to implement the different technologies used in the NuDiVe exercise and necessary to accomplish the objectives of the exercise[1].

Core skills:

- The agreed TAI dismantlement inspection procedures;
- Nuclear material safety and security knowledge;
- The ability to perform "on-site radiation signatures measurement" of nuclear material with the radiological measurements equipments (detection portal, radiological measurement handsets);
- Experience and knowledge in the implementation of CoC equipment (tags, seals, unique identifier).

Other possible skills may include:

- Nuclear physics/nuclear engineering;
- Maintenance of inspection equipment;
- The handling of special nuclear materials;

[1] A training will be proposed

2

- Information and cybersecurity skills, if remote monitoring instruments are provided;
- Knowledge of nuclear weapons;
- Knowledge in radiation safety;
- Health and safety professionals, particularly those from nuclear and high explosives facilities[2], with a mix of skills that allows them to provide situational awareness to their colleagues, and conduct safety functions as necessary.

2. Host team skills

Many of the **skills and the knowledge base that is required of an inspection team member are consistent with those required by an inspected State escort team / host team**. The presence of technical specialists on the escort team would provide the escort team with their own experts who would be able to address any questions or concerns expressed by the inspection team.

Additional technical skills for the host team could therefore be:

- Background experience in facility design or operation, not only for NEDs but also for any other military or nuclear processing activities;
- Knowledge in health and safety, particularly those from nuclear and high explosives facilities;
- Previous experience with other arms control inspection regimes, nuclear inspection experience;
- Knowledge of nuclear weapons ;

A **Host Team Leader** would be a senior escort, preferably with nuclear weapons-related, or similar OSI experience, and with:

- Detailed knowledge of the requirements set forth in the verification agreement and any subsidiary enabling or implementing agreements;
- Negotiating skills;
- Report-writing skills based on factual findings; and
- A strong understanding of facility health and safety procedures and requirements.

3. Observers team

All skills and knowledge identified for inspection and host team are relevant for observers. A large panel of expertise among the observers is actually necessary to provide a comprehensive and enlightened understanding of the inspection activities, and to be able to report and assess them with sufficient criticism.

[2] No HE in the NuDiVe exercise

3

C.2. Participation form

NuDiVe Participation form

Name ____________________________________

Organisation ____________________________________

Email address ____________________________________

I wish to join the

- **Inspectors' team** ☐
- **Host team** ☐
- **Observers' team** ☐

I have the following skills and experiences:

Core inspection-related skills

Administrative procedures related to the verification regime (i.e., POE/POE exit procedures, setting-up an Inspector Station, etc.)	☐
Previous experience with other arms control inspection regimes—nuclear inspection experience is desired but not necessary so long as the individual can prove they have the necessary skills and knowledge to support the work of the team	☐
Ability to ensure that chain of custody and physical security procedures are followed	☐
Negotiation skills	☐
Report-writing skills based on factual findings	☐

Other helpful inspection-related skills

Team management skills	☐
Confidentiality and security procedures, including team security and boundary control	☐
Logistics support required to support the team during the course of inspections	☐
Knowledge in health and safety, particularly those from nuclear and high explosives facilities, including radiation protection	☐
Diplomatic or legal experience who could be helpful in resolving disagreements during inspection activities	☐
Military or other deployed operational experience that enables them to help others operate in an unfamiliar environment	☐

Background experience in facility design or operation, not only for NEDs but also for any other military or nuclear processing activities	☐
Other relevant inspection-related skills, please specify:	

Core technical skills

Knowledge of agreed TAI dismantlement inspection procedures	☐
Nuclear material safety and security knowledge	☐
Ability to perform "on-site radiation signatures measurement" of nuclear material with the radiological measurements equipment (detection portal, radiological measurement handsets)	☐
Experience and knowledge in the implementation of CoC equipment (tags, seals, unique identifier)	☐

Other helpful technical skills

Nuclear physics/nuclear engineering	☐
Maintenance of inspection equipment	☐
Handling of special nuclear materials	☐
Knowledge of nuclear weapons	☐
Information and cybersecurity skills, if remote monitoring instruments are provided	☐
Knowledge in radiation safety	☐
Health and safety professional experience, allowing to provide situational awareness to colleagues, and conduct safety functions as necessary	☐
Other relevant technical skills, please specify:	

D. Schedule

D. Schedule

Monday

	Host Room: 377	Inspectors Room: 236	Evaluators' Room: 287	Organisers Room: 334	
Mon	**Host**	**Insp**	**Evaluator**	**Organiser**	**Extra**
7:30					
7:45			Pick up at Hotel Aquis Grana, Aachen		
8:00	Pick up at Hotel Dorint, Düren			Pick up at Stadthotel, Jülich	
8:15				Arrival at IEK-6	
8:30	Arrival at IEK-6	Pick up at Hotel Benelux, Aachen	Arrival at IEK-6		
8:45					
9:00	Check of Inspectors	Arrival at IEK-6 / Check by Host			
9:15	Welcome	Welcome			
9:30	Briefing/familiarisation	Briefing/familiarisation			
9:45					
10:00					
10:15					
10:30					
10:45		Break			
11:00	Break	Briefing/familiarisation			
11:15	1st site visit, **controlled area**				
11:30					
11:45					
12:00		Lunch; **Foyer**			
12:15					
12:30	Lunch; **Casino**				
12:45					
13:00		Briefing/familiarisation			
13:15					
13:30					
13:45	Briefing/familiarisation				
14:00					
14:15		Break			
14:30		Team Meeting/Work on inspection plan			
14:45	Break				
15:00	Briefing/familiarisation				
15:15					
15:30					
15:45	Team Meeting/Prepare Site Briefing				
16:00					
16:15					
16:30					
16:45					
17:00					
17:15					
17:30	Pick up at IEK-6	Pick up at IEK-6	Pick up at IEK-6	Hot wash Room 377	
17:45					
18:00	Arrival at Dorint Hotel, Düren			Pick up at IEK-6	
18:15		Arrival at Hotel Benelux, Aachen	Arrival at Hotel Aquis Grana, Aachen	Arrival at Stadthotel, Jülich	
18:30					
18:45					
19:00					
19:15					
19:30					
19:45					
20:00					
20:15					
20:30					
20:45					
21:00					

			Tuesday		
	Host Room: 377	**Inspectors Room: 236**	**Evaluators' Room: 287**	**Organisers Room: 334**	
Tue	**Host**	**Insp**	**Evaluator**	**Organiser**	**Extra**
7:30					
7:45					
8:00			Pick up at Hotel Aquis Grana, Aachen		
8:15	Pick up at Hotel Dorint, Düren			Pick up at Stadthotel, Jülich	
8:30		Pick up at Hotel Benelux, Aachen		Arrival at IEK-6	
8:45	Arrival at IEK-6		Arrival at IEK-6		
9:00	Check of Inspectors	Arrival at IEK-6 / Check by Host			
9:15	Briefing/familiarisation	Briefing/familiarisation			
9:30					
9:45	2nd site visit; **controlled area**				
10:00					
10:15					
10:30					
10:45	Briefing/familiarisation	Break			
11:00		Team Meeting/Work on inspection plan			
11:15					
11:30					
11:45					
12:00					
12:15	Lunch; **Casino**	Lunch; **Foyer**			
12:30					
12:45					
13:00					
13:15					
13:30	***Start of inspection***: First Host-Inspector Meeting; Room 377 or 236				
13:45	Welcome				
14:00	Host Site Briefing for Inspectors				
14:15					
14:30	Inspection Plan Briefing for Host				
14:45					
15:00	Break				
15:15	Negotiations as teams see fit				
15:30					
15:45					
16:00					
16:15					
16:30	Team Meeting	Team Meeting			
16:45					
17:00					
17:15					
17:30	Pick up at IEK-6	Pick up at IEK-6	Pick up at IEK-6	Hot wash; **Room 377**	
17:45					
18:00	Arrival at Dorint Hotel, Düren			Pick up at IEK-6	
18:15		Arrival at Hotel Benelux, Aachen	Arrival at Hotel Aquis Grana, Aachen	Arrival at Stadthotel, Jülich	
18:30					
18:45					
19:00					
19:15					
19:30					
19:45					
20:00					
20:15					
20:30					
20:45					
21:00					

D. Schedule

	Wednesday				
	Building 5.3, Host Room: 377	**Inspectors Room: 236**	**Evaluators' Room: 287**	**Organisers Room: 334**	
Wed	**Host**	**Insp**	**Evaluator**	**Organiser**	**Extra: Visit of Ambassadors Beerwerth and Hwang**
7:30					
7:45					
8:00			Pick up at Hotel Aquis Grana, Aachen		
8:15	Pick up at Hotel Dorint, Düren			Pick up at Stadthotel, Jülich	
8:30		Pick up at Hotel Benelux, Aachen		Arrival at IEK-6	
8:45	Arrival at IEK-6		Arrival at IEK-6		
9:00	Check of Inspectors	Arrival at IEK-6 / Check by Host			
9:15	Inspection activities and negotiations as teams see fit				
9:30					
9:45					
10:00					
10:15					
10:30					
10:45					
11:00					
11:15					
11:30					
11:45					
12:00					Welcome of Ambassadors Beerwerth and Hwang, business lunch and presentation of the NuDiVe exercise; **Building 4.8W, Rooms 233/234**
12:15	Lunch; **Casino**	Lunch; **Foyer**			
12:30					
12:45					
13:00					
13:15	Inspection activities and negotiations as teams see fit				
13:30					
13:45					
14:00					
14:15					Observation of the NuDiVe Exercise; **controlled area**
14:30					
14:45					
15:00					
15:15					
15:30					
15:45					
16:00					
16:15					
16:30	Team Meeting	Team Meeting			Discussion on "Nuclear Disarmament Verification Challenges", with IPNDV members; **Building 4.8W, Rooms 233/234**
16:45					
17:00					
17:15				Hot wash	
17:30					
17:45	17:55 Group photo; **Central Library**				
18:00	Reception with introductory remarks by Ambassadors Beerwerth and Hwang: **Central Library - Foyer**				
18:15					
18:30					
18:45					
19:00					
19:15					
19:30					
19:45					
20:00	Pick up at Central Libary	Pick up at Central Libary	Pick up at Central Libary	Pick up at Central Libary	Pick up at Central Libary
20:15				Arrival at Stadthotel, Jülich	
20:30	Arrival at Dorint Hotel, Düren				
20:45		Arrival at Hotel Benelux, Aachen	Arrival at Hotel Aquis Grana, Aachen		
21:00					Arrival at Hotel, Düsseldorf

Thursday

	Building 5.3, Host Room: 377	Inspectors Room: 236	Evaluators' Room: 287	Organisers Room: 334	
Thu	**Host**	**Insp**	**Evaluator**	**Organiser**	**Extra**
7:30					
7:45					
8:00			Pick up at Hotel Aquis Grana, Aachen		
8:15	Pick up at Hotel Dorint, Düren			Pick up at Stadthotel, Jülich	
8:30		Pick up at Hotel Benelux, Aachen		Arrival at IEK-6	
8:45	Arrival at IEK-6		Arrival at IEK-6		
9:00	Check of Inspectors	Arrival at IEK-6 / Check by Host			
9:15	Inspection activities and negotiations as teams see fit				
9:30					
9:45					
10:00					
10:15					
10:30					
10:45					
11:00					
11:15					
11:30					
11:45					
12:00					
12:15	Lunch; **Casino**	Lunch; **Foyer**			
12:30					
12:45					
13:00					
13:15	Inspection activities and negotiations as teams see fit				
13:30					
13:45					
14:00					
14:15					
14:30					
14:45					
15:00					
15:15					
15:30					
15:45					
16:00					
16:15					
16:30	Team Meeting	Team Meeting			
16:45					
17:00					
17:15					
17:30					
17:45	Pick up at IEK-6	Pick up at IEK-6	Pick up at IEK-6	Hot wash; **Room 377**	
18:00					
18:15	Arrival at Dorint Hotel, Düren			Pick up at IEK-6	
18:30		Arrival at Hotel Benelux, Aachen	Arrival at Hotel Aquis Grana, Aachen	Arrival at Stadthotel, Jülich	
18:45					
19:00					
19:15					
19:30					
19:45					
20:00					
20:15					
20:30					
20:45					
21:00					
21:15					

D. Schedule

	Friday				
	Building 5.3, Host Room: 377	**Inspectors Room: 236**	**Evaluators' Room: 287**	**Organisers Room: 334**	
Fri	**Host**	**Insp**	**Evaluator**	**Organiser**	**Extra**
7:30					
7:45					
8:00			Pick up at Hotel Aquis Grana, Aachen		
8:15	Pick up at Hotel Dorint, Düren			Pick up at Stadthotel, Jülich	
8:30		Pick up at Hotel Benelux, Aachen		Arrival at IEK-6	
8:45	Arrival at IEK-6		Arrival at IEK-6		
9:00	Check of Inspectors	Arrival at IEK-6 / Check by Host			
9:15	Inspection activities and negotiations as teams see fit				
9:30					
9:45					
10:00					
10:15					
10:30					
10:45					
11:00					
11:15					
11:30					
11:45					
12:00					
12:15	***End of inspection***				
12:30	Joint Lunch; **Casino - Faculty Club**				
12:45					
13:00					
13:15					
13:30					
13:45					
14:00	Debriefing; **Building 6.2, Room 406**				
14:15					
14:30					
14:45					
15:00					
15:15					
15:30					
15:45					
16:00	Pick-up at IEK-6			De-briefing; **Room 377**	
16:15					
16:30					
16:45					
17:00				Pick-up at IEK-6	
17:15					
17:30					
17:45					
18:00					

E. Manuals and equipment

E.1. Surrogate radiation source

Gerald Kirchner
Univ. Hamburg
Germany

February 5, 2019

Estimating the γ and neutron source strengths of Pu

The following calculations intend to estimate the gamma intensity of a small piece of plutonium metal and to provide potential surrogate isotope sources for the planned GER-FRA NuDiVe exercise. Uncertainties of the following estimates are approx. 25 %.

1. Basic assumptions

- 50 g of Pu metal, δ-phase, 30 years after separation
- isotopic composition:

Isotope	At separation [%]	After 30 y [%]	[GBq]
^{239}Pu	95.	95.	109.
^{240}Pu	4.7	4.7	19.7
^{241}Pu	0.3	0.1	
^{241}Am	0.	0.2	12.6

- size 2.5 cm x 2.5 cm x 0.5 cm
- no external shielding

2. Self shielding of γ

Due to its high density, low energy gamma rays are effectively attenuated within the plutonium. It is assumed that all gammas detected are emitted from the layer within which the gammy intensity is reduced to 50 % (half-thickness). If attenuation within this layer is neglected, an *effective mass*, from which the radiation originates, can be calculated. Using the mass attenuation coefficients given by Reilly (2007), the following *effective masses* result for gammay rays emitted from the 2.5 x 2.5 cm^2 plane of the Pu metal:

1

γ Energy [keV]	Half-thickness [mm]	Effective mass [g]
60	0.063	0.62
100	0.24	2.37
150	0.16	1.58
200	0.34	3.36
250	0.58	5.73
300	0.84	8.29
350	1.22	12.0
400	1.51	14.9
450	1.87	18.5
500	2.19	21.6
550	2.58	25.5
600	3.03	29.9
650	3.30	32.6
700	3.66	36.1

3. Gamma intensities

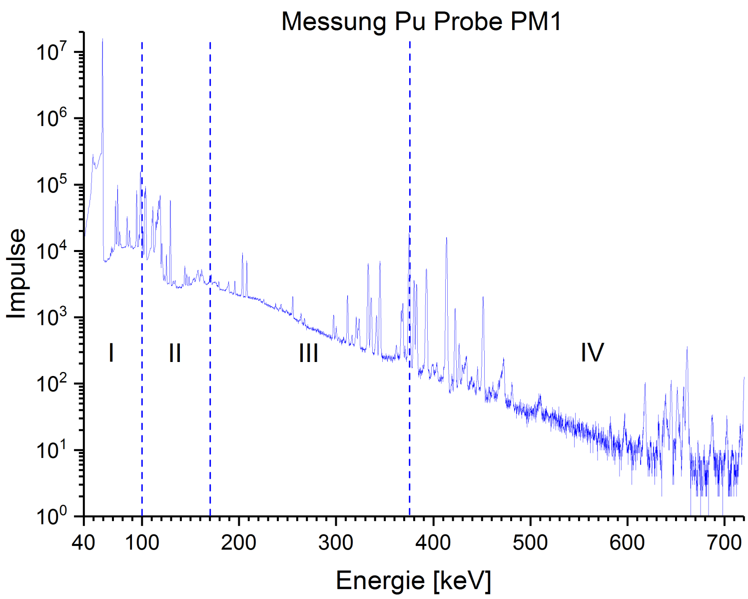
Since ^{239}Pu has many gamma lines with very low emission probabilities, the following is limited to the lines showing the most prominent branching ratios (as given by Reilly (2007)). If an energy interval is given in the following table, various individual lines with adjacent decay energies are combined. The emissions specified take into account self shielding, mass, geometry and isotopic composition of the plutonium.

Isotope	Energy [keV]	Branching ratio [10^{-5}]	Emissions [10^5 s^{-1}]
^{239}Pu	94-99	12.2	6.3
	110-116	4.22	3.0
	130	6.26	1.5
	142-146	1.47	0.51
	332-345	1.21	2.9
	375-393	2.69	7.9
	414	1.49	5.2
	451	0.19	0.77
^{240}Pu	94-98	0.16	0.015
	160	0.40	0.030
^{241}Am	60	35900.	560.
	97-103	49.9	3.0
	113-117	0.94	0.081
	122-125	5.09	0.074
	322-335	0.80	0.20

A total gamma flux of approx. $3.2 \cdot 10^6$ s^{-1} results shortly after separation (or purification) of the plutonium which due to the buildup of ^{241}Am increases to approx. $5.9 \cdot 10^7$ s^{-1} for aged plutonium.

2

For comparison the following figure shows the spectrum of a plutonium sample of similar mass and isotopic composition, which we measured some years ago (Weil, 2013).



Surrogate sources (1): γ emitters

Any radioacive source to be used instead of 50 g of real plutonium should show a comparable total gamma ray intensity and cover a similar energy spectrum. The following radioisotopes could reasonably meet these criteria.

Isotope	Half-life [y]	γ flux [Bq^{-1}]	Energy [keV]	Branching ratio
^{133}Ba	10.9	1.40	81.	0.36
			276.4	0.08
			302.7	0.20
			355.9	0.67
			383.7	0.09
^{57}Co	0.74	0.97	122.0	0.86
			136.5	0.11
^{109}Cd	1.23	0.04	88.0	0.04
^{155}Eu	4.96	0.52	87.0	0.31
			105.3	0.21
^{75}Se	0.33	1.51	121.1	0.17
			136.	0.56
			264.5	0.58
			279.5	0.25
			400.7	0.12

3

The list has been limited to radioisotopes, which often are used for detector calibration. These usually are point sources or thin disks to limit any self-shielding effect. It can be expected that sources of the required activity of these radionuclides will be commercially available, if radioactive measurements shall be included in our exercise.

Surrogate sources (2): neutron emitters

With a spontaneous fission neutron yield of $1.0 \cdot 10^3$ g^{-1} s^{-1} (Reilly, 2007), a neutron flux of $2.4 \cdot 10^3$ s^{-1} is calculated for the plutonium metal specified above. Additional neutrons produced by induced fission are not taken into account because of the small Pu mass.

Due to its common commercial availability, ^{252}Cf is a suitable surrogate. With its high spontaneous fission neutron yield of $2.3 \cdot 10^{12}$ g^{-1} s^{-1} (Reilly, 2007), a ^{252}Cf source of $2.1 \cdot 10^4$ Bq will generate a neutron flux similar to the Pu metal.

References

Reilly, T. D.: Passive Nondestructive Assay of Nuclear Materials, 2007 Addendum. Los Alamos National Laboratory, 2007.

Weil, M.: Nuclear Disarmament Verification: Gamma-spectrometry for Information Barriers (in German). Diploma Thesis, Univ. Hamburg, 2013

4

E.2. Gamma detector »Identifinder«

GAMMA DETECTOR

identiFINDER

OPERATING MANUAL

1

Contents

1 Overview

The ICx identiFINDER instrument is a digital hand-held battery-powered instrument that can be used to search for single sources of gamma radiation or scan areas contaminated with gamma emitting radionuclides. It measures the gamma dose and the dose rate using automated physics algorithms.

The simple user interface is designed such that it can be successfully operated by personnel with a minimum of training. The high degree of automation enables successful operation even in a distracting and hostile environment.

It also incorporates a feature for automatic identification of radionuclides by analysis of gamma ray spectra, that is disabled/not used in the NuDiVe environment. Although this feature could measure classified attributes, it is not a harm to the NuDiVe operation since the detector is host operated and at no time in the hands of an inspector.

This manual includes only those information and steps of operation that are necessary for the NuDiVe inspection.

2 Design and Technical Features

2.1 Design

Front view of the detector:

1. NaI(Tl) scintillation detector
2. Command line
3. Selection buttons L, M & R
4. Red LED (gamma alarm)
5. ON/OFF button
6. Battery compartment lock

The detector's display is divided in three principle areas:

TOP: *Status Bar*

This area the current status of the energy calibration (“S” for functioning, “N” for nonfunctioning) and the current battery status.

CENTER: *Variable Main Display*

Depending on the chosen mode, it shows, for example, status information after power up, the dose rate of the observed gamma radiation or a dose rate time diagram.

BOTTOM: *Key Descriptions*

4

This part of the display shows a black shadowed command line with up to three commands which can be executed using one of the buttons “L”, “M” or “R” for left, middle and right keys, respectively.

2.2 Technical Features

- Display type: Monochrome LCD with backlight (61x43mm)
- Dimensions: 235 mm x 93 mm x 75 mm (W x D x H)
- Weight: 1250 g including batteries
- Operating Temperature: -15°C to +55 °C
- Relative Humidity: 10 % - 80 %, non condensing
- Protection class: IP54 (Splash proof, dust tight)
- Operating Duration: ~8 h
- Alarm indicators: Light (red and blue LEDs), sound and vibration
- Detectors: NaI(Tl) (Ø 1.4" x 2") and
  GM tube (for high dose rates)
- Energy Range: 30 keV - 3 MeV
- Sensitivity (^{137}Cs): >500 cps per Sv/h
- Dose rate range total: 0,01 µSv/h – 1 Sv/h
  - Dose rate range NaI: 0,01 µSv/h – 500 µSv/h
  - Dose rate range GM tube: 500 µSv/h – 1 Sv/h
- Dose range: 0,01 µSv - 1 Sv

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3 Operating instructions

3.1 Start-up sequence

To switch on the instrument press the ON/OFF button until the red alarm LED illuminates. Soon the display will show the initialization screen:

Figure 1: startup screen

After start-up the energy calibration of the detector starts. Within about 20 seconds the high voltage and the fine gain will be adjusted according to the measured gamma ray spectrum of the calibration source (i.e. Cs-137).

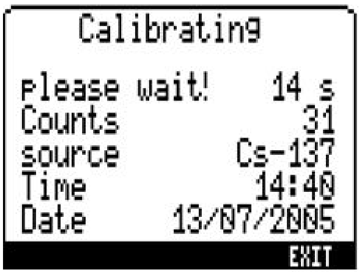

Figure 2: calibration

A successful calibration ends with a message and the display of fine gain and HV values. If the calibration cannot be finished correctly an error message shows up. The device can in this case still be used to search and locate gamma sources, but will have problems with isotope identification (not used in NuDiVe). It will show an “N” in the upper right hand corner from then on. An “S” instead indicates a functioning calibration.

The detector is now ready for operation and enters automatically into the DOSE rate mode.

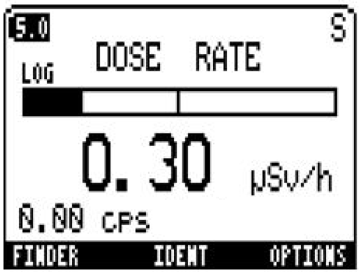

Figure 3: DOSE rate mode

The DOSE rate screen is the detector's basic screen. All other functions can be accessed from this screen by means of the "L", "M" and "R" buttons.

3.2 Operation Modes

In the standard configuration the identiFINDER allows to access different user screens (measuring modes) which provide for

1. Gamma dose and gamma dose rate measurements (DOSE rate mode),
2. Search for single radioactive gamma sources or for areas of contamination with gamma radio nuclides (FINDER mode),
3. Automatic identification of radio nuclides based on measured gamma ray spectra (IDENTification mode).

The Nuclide Identification (IDENT) Mode, which allows the identification of radionuclides through comparing the measured energy spectrum with a spectrum library, will not be explained in detail as it is not to be used.

3.2.1 DOSE Rate Mode

The DOSE rate mode is the starting point for all other identiFINDER features. Figure 4 shows the DOSE screen which automatically appears when the startup procedure is finished successfully.

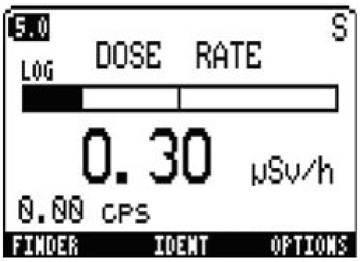

Figure 4: DOSE rate mode

On the DOSE screen the gamma dose rate - or more precisely the ambient dose rate equivalent H*(10) - is numerically and graphically displayed.

The length of the horizontal black bar represents the actual dose rate reading in a logarithmic scale. The limits are 0.01 µSv/h up to 1 Sv/h. The small vertical separator (here above the number ”30”) displays the dose alarm value.

Additionally the gamma count rate in counts per seconds (cps) is given in this display.

By pressing the left (“FINDER”) or middle (“IDENT”) button the detector is switched to the FINDER or the IDENTification mode. By choosing the right key (“OPTIONS”) one enters the detector’s settings menu.

If the detected radioactivity exceeds the alarm levels, a warning message will be shown on the top line of the display.

3.2.2 FINDER Mode

The FINDER mode can be used to localize the radiation source if an increase of the dose rate level is detected. Follow the display and the acoustic signals to easily locate the source or contamination.

From the DOSE rate mode the FINDER mode can be entered by pressing the left button. The detector will now switch to the FINDER screen shown in Figure 5.

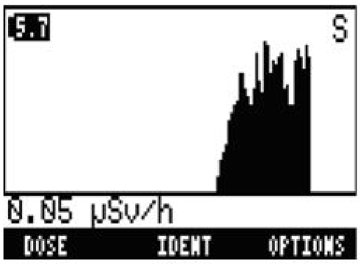

Figure 5: FINDER mode (1)

The initial screen is empty and starts being filled from right to left by a histogram representing the actual dose rate reading shown in the bottom line.

In general: The higher the bar the closer the source.

A typical course of a search for a hidden source is shown in the three figures (Figure 5 to Figure 7).

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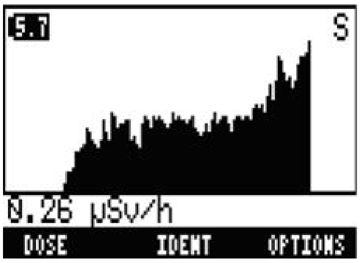

Figure 6: FINDER mode (2)

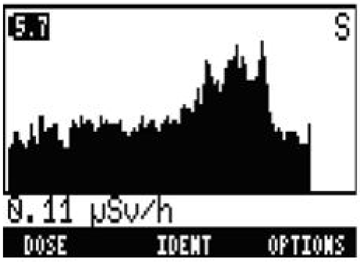

Figure 7: FINDER mode (3)

When starting the search (Figure 5) the detector is far away from the source and is moved gradually towards it (Figure 6). The actual dose rate reading is 0.26 Sv/h which is indicated by the vertical bar most right. Afterwards the detector is shifted away (Figure 7), the source is located.

3.3 Shut down

To switch off the identiFINDER press the ON/OFF button until a tone sounds - simultaneously the display will show “POWER OFF”.

4 Battery indication and charging

The actual measured voltage is shown in the battery symbol 5.4 at the upper left hand corner of the display. Typical values are 5V for fully charged batteries or 6V in case the detector is currently being charged.

In case of the message “Low Battery Warning” accompanied by an audible signal the power will break down within a few minutes. If the voltage drops below 3.9V, the device will switch off immediately.

To recharge the detector, use the battery charger cable to connect it to a mains socket. On the back side of the device are two LED indicating the state of charging:

The green LED on the right hand side illuminates when the external power supply is connected to the detector, the orange LED on the left hand side is switched on only while the detector is currently being charged up in trickle charge mode.

5 General recommendations

The ICx identiFINDER is optimized for single-handed operation. The detector should point to the object to be surveyed while you watch the display and control the instrument by pressing the keys with your thumb.

6 Safety regulations

The ICx identiFINDER is designed for outdoor use. When operated in accordance with the operating instructions it should not present any hazard to the operator.

The housing is essential to the integrity and safe operation of the instrument. Under no circumstances should the housing be tampered with, penetrated, or otherwise removed except for normal access to the external connectors.

The ICx identiFINDER uses scintillation crystals (among other probes) to detect gamma radiation. Scintillation detector crystals are extremely brittle. Handle the instrument with utmost care and never drop it.

E.3. Neutron detector »Igor«

NEUTRON SEARCH DETECTOR

KSAR1U.06

OPERATING MANUAL

1

Contents

1 Overview

The KSAR1U.06 (nickname „Igor“) is a hand-held neutron search detector designed for searching and localization of neutron radiation sources. For this purpose it measures the neutron count rate with its sensitivity maximised for the detection of fission neutrons.

The KSAR1U.06 is an efficient tool as a primary search (detection) device or as a complimentary device to be used for the verification of alarm signals generated by fix-installed radiation systems. It has a rugged design for outdoor use in a wide range of temperature and humidity as well as a clear interface with both digital and graphical indication simplifying the neutron source localization. The rechargeable NiMH batteries provide for at least 8 hours of continuous operation.

Depending on the user's choice internal statistical algorithms calculate alarm thresholds with respect to the measured background level (outdoor neutron background level is typically between 0.04 - 0.3 cps). When exceeded, the device will automatically activate three alarm indicators: acoustic signal (tone height proportional to height above alarm threshold), alarm light and vibrations.

In addition to the neutron detector, the device also contains a Geiger-Müller Counter measuring the gamma radiation count rate. It is designed for the approximate estimation of the ambient dose rate to warn the user in case a radiologically relevant radiation exposure is detected. To that end it approximates a dose rate by the measured count rate as no direct measurement of the dose rate or the energy spectrum is possible with this neutron search detector.

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2 Design and Technical Features

The neutron search detector KSAR1U.06 is developed and built in compliance with International Atomic Energy Agency recommendations and requirements "Technical / Functional Specifications for Border Radiation Monitoring Equipment Draft Rev. 18.5 / 19 Dec. 2003".

2.1 Design

The neutron detector is a hand-held detector with two lightweight carrying handles: one on the top and one on the front. Also on the front side are the LCD display, the two operational buttons F1 and F2 as well as a third button to power on/off the device or to illuminate the display when necessary. Next to the "Power/illumination On/Off" button are a piezoelectric siren for the acoustic alarm and a LED light for the visual alarm.

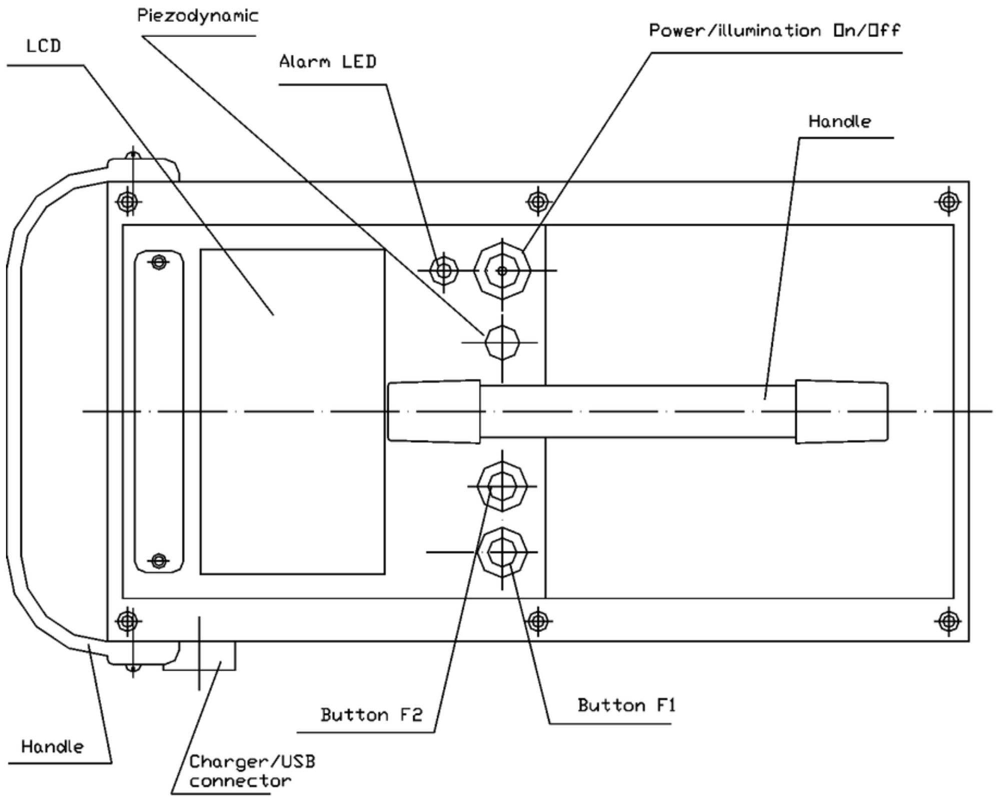

Figure 1: Top view of the detector

On the left side of the device is a connector to connect the detector with a computer via USB and a connector to recharge the detector's battery. Inside the device one finds a vibromotor generating an additional third alarm signal by making it vibrate.

The detectors itself consists of three He-3-filled tubes for neutron counting and another smaller tube for gamma-detection on top of the device (see Figure 2). For neutron detection the rear side of the device should face the surface to be measured as it is the most sensitive. To facilitate handling, the most sensitive spots on the device for both gamma and neutron detection are marked by crosses.

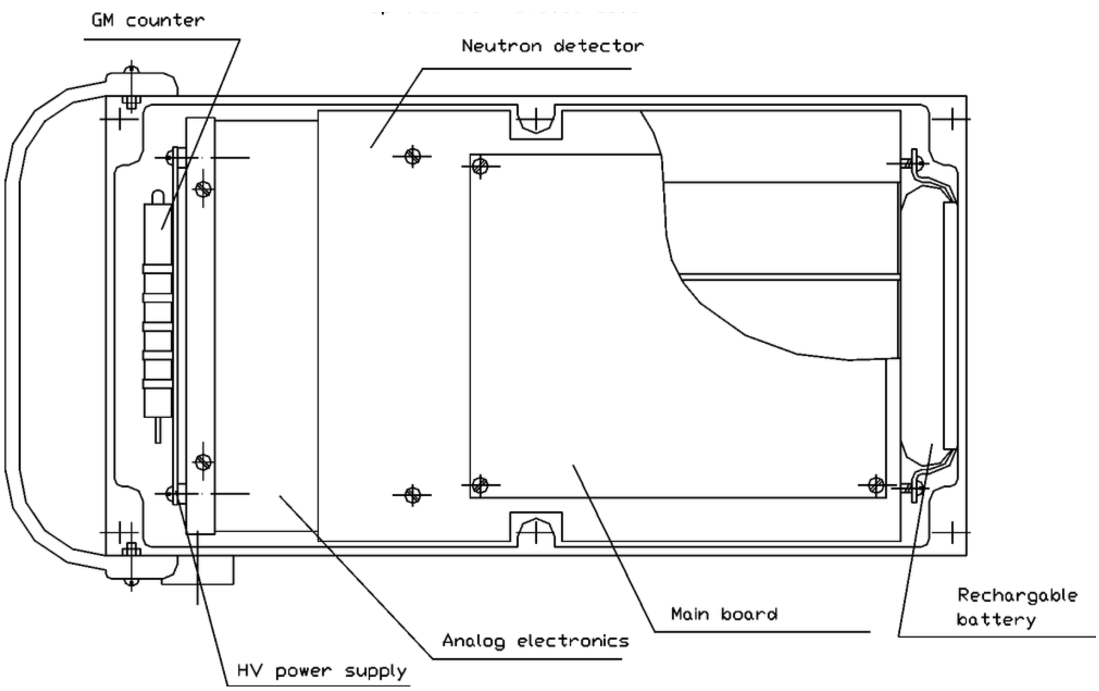

Figure 2: Top view of the detector with removed cover

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2.2 Technical Features

- Total weight: 4.3 kg
- Outside dimensions: 30 x 16 x 13 cm
- International protection rating: IP55
- Rechargeable NiMH-battery: lasts approx. 8 hours
- Detector triggers an alarm when a neutron source 1.2×10^4 n/s is passed by with a speed of 0.5 m/s in standard background conditions at the distance of (1±0.05) m of the closest approach. Alarm probability is 0.8 at 95% of confidence level.

Neutron detector:

- three ^{3}He proportional counters (with polyethylene-moderator)
- dimensions of the ^{3}He tubes: diameter 32 mm, length 20 cm
- ^{3}He pressure inside the counters is 3 atm
- sensitivity optimized for the energy range 10 keV – 1000 keV
- allowed ambient temperature range from -20 °C up to +50 °C
- measuring range from 0.01 up to 6000 cps
- static detection sensitivity to fission neutrons not less than 20 cm^2

Gamma detector:

- SBM-20 Geiger-Müller tube
- intended for the detection and evaluation of the gamma ray ambient dose rate over the energy range 0.06 - 3 MeV
- the range of indicated ambient gamma dose rate is 0.14 - 1400 µSv/h with 35 % uncertainty

3 Operating instructions

Three buttons are available for the operation of the device. The ⏻-button is to switch on the device, turn it off or to illuminate the display. The other two operating buttons F1 and F2 have various functions that are always indicated in the lower left corner of the display as discussed in the following sections. In the lower right corner of the screen the time is shown as well as the battery status in form of a rectangle that is filled when the battery is full while a blank frame indicates that the battery is to be charged. If the latter is the case an acoustic signal (0.5 s, 0.5 kHz) is generated at 10 s intervals.

3.1 Start-up sequence

To turn the Neutron Search Detector on press the ⏻-button for 1 second and then the F1-button. It will check the proper functioning of its components and start a warm-up phase lasting 60 s.

Figure 3: Warm Up screen view

Finally, an automatic measurement will begin averaging the background signal over 300 s and storing this value for later comparison. After the start-up sequence the device will automatically turn into SEARCH mode.

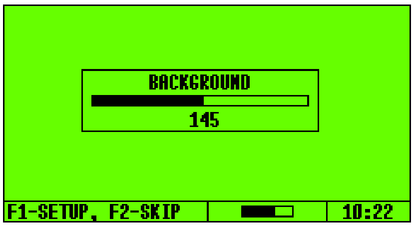

Figure 4: Background measurement screen view

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BACKGROUND mode can be cancelled providing that there is a previously taken background value in the instrument's memory. Pressing the button F1 turns the detector into SETUP mode.

If during the background measurement no neutron counts were detected, the system warns about a fatal malfunction. Push F-1 button to repeat the background measurement.

In BACKGROUND mode the count rate in the gamma-ray detection channel (GM counter) is analysed as well. Contrary to the above mentioned neutron malfunction, gamma-ray malfunctioning is not a fatal error and after displaying the corresponding message the detector allows the operator to continue operation by pressing any button.

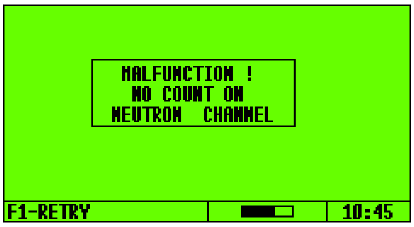

Figure 5: No neutron counts screen view

On completion of the background measurement, the detector turns into the SEARCH mode.

3.2 Operation Modes

The detector's modes of operation a user can choose of are SEARCH, INTEGRAL and SETUP. In the following there is a description of these modes.

3.2.1 Scanning Measurement (SEARCH mode)

SEARCH mode is used for the search and localisation of neutron sources. After start-up the device will automatically turn into SEARCH mode. The display will show a diagram of the count rate (averaged over 2s) of the last 70 seconds plotted against the time. Scaling is controlled automatically.

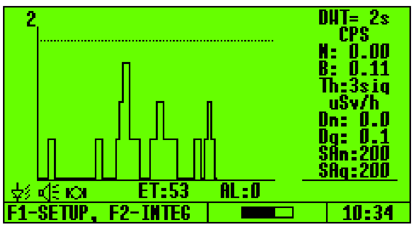

Figure 6: SEARCH mode screen view

In the upper right corner of the screen the specified sampling time (DWT), the current neutron count rate (N), the averaged neutron background count rate (B) and the alarm threshold in standard statistical deviation units (Th) is indicated.

Neutron (Dn) and gamma ray (Dg) ambient dose rate values and specified radiological safety alarm thresholds (SAn and SAg) in µSv/h are indicated beneath. The dose rate updating interval is 10 s and is not user-selectable in contrast to the sampling time and the detection threshold.

Active alarm indicators (LED, acoustic and vibro) are displayed under the diagram with the corresponding symbols. All three indicators are switchable and can be activated / deactivated independently in the SETUP mode. The alarm indicators will alert when the selected alarm threshold (Th) in terms of standard deviations of the background count rate is exceeded. In the diagram this threshold is illustrated by a dotted line.

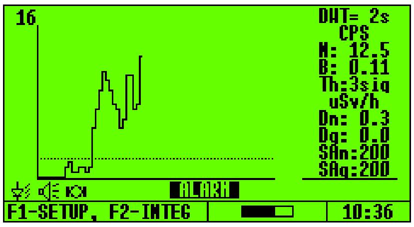

Figure 7: SEARCH mode screen view on exceeding alarm threshold

A circular buffer for alarm related information recording is provided for the device. Alarm time, date, sampling time, N , sigma multiplier and B are stored in one record. The buffer capacity is 4096 records. A single alarm is recorded in the list in the vicinity of 5 preceding and 5 posterior measurement intervals. Data from the detector's memory can be read out with a PC.

The detector can be shifted in SETUP or INTEGRAL mode by pressing the F1 or F2 button.

3.2.2 Time-Integrated Measurement (INTEGRAL mode)

INTEGRAL mode is intended to detect and verify weak neutron sources that cannot be detected in the SEARCH mode because of its limited measurement time. It provides an integrating measurement of the neutron count rate until stopped at an arbitrary time. Fig. 8 shows the INTEGRAL mode screen view.

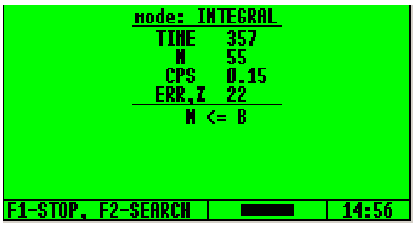

Figure 8: INTEGRAL mode screen view

The detector displays the following items in this mode:

TIME – Elapsed time (since START button (F1) was pressed)

N – Number of neutron counts accumulated since START button (F1) was pressed

CPS – Average count rate over the elapsed time, CPS = N/TIME

ERR – statistical uncertainty of average count rate with confidence level 0.95

The data are updated on the screen once a second.

On pressing the STOP (F1) button the detector compares N and the background counts B and generates the message “N > B” if the threshold is exceeded. Otherwise the “N ≤ B” message is displayed.

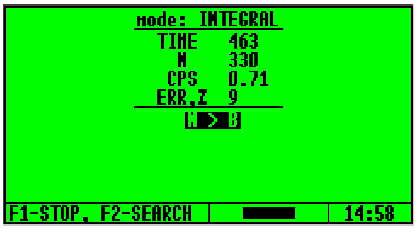

Figure 9: INTEGRAL mode screen view on exceeding background

Once stopped, the measurement can not be continued. A measurement cycle will be repeated on pressing the F1 button. The device will return into SEARCH mode if the F2 button is pressed.

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3.2.3 Changing settings (SETUP mode)

The main menu of the SETUP mode is shown in Fig. 10.

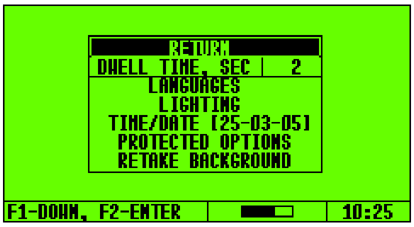

Figure 10: Main menu of the SETUP mode

A menu option is realized by pressing the F1-button to select the option followed by the F2-button to confirm the choice. When the F2-button is pressed in “RETURN” option, the device returns to the previous mode. The device gets in BACKGROUND mode in case the “RETAKE BACKGROUND” option is chosen. Sampling time in SEARCH mode is specified by the option “DWELL TIME” and varies from 1 to 10 s (step 1 s).

The illumination of the screen is controlled by the “LIGHTING” submenu.

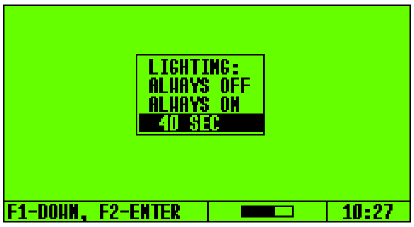

Figure 11: Illumination control panel

The display illumination remains switched off in case the “ALWAYS OFF” option is chosen apart from the illumination for 40 s each time the ⏻-button is pressed briefly.

The display is permanently illuminated in the “ALWAYS ON” mode.

The “40 SEC” mode illuminates the display for 40 s at every press on any button, at changing operation modes (including automatic modes), at exceeding of the detection threshold in SEARCH mode, and at exceeding the radiological safety alarm threshold. Note, that the display illumination is one of the most power consuming features. Avoiding a frequent use of the “ALWAYS ON” option provides a longer operational life time without recharging the batteries.

To enter into PROTECTED OPTIONS, the password “1111” is required (Fig. 12).

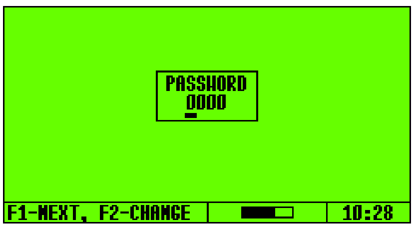

Figure 12: Entering password

A value above the marker shifts from 0 to 9 by pressing F2. To shift to the next digit press the F1 button. When the last digit of the password is entered, in case the password is correct, the menu of the PROTECTED OPTIONS is displayed on the screen, otherwise message "ILLEGAL PASSWORD" appears on the screen. Pressing any button returns the device into the previous mode.

The menu of the PROTECTED OPTIONS is shown in Fig. 13.

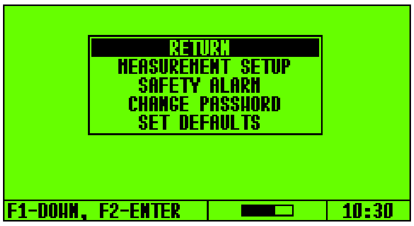

Figure 13: PROTECTED OPTIONS menu

When F2 button is pressed in "RETURN" option, the device returns to the SETUP mode. Changing settings of the BACKGROUND and SEARCH mode is realized in the submenu "MEASUREMENT OPTIONS" (Fig. 14).

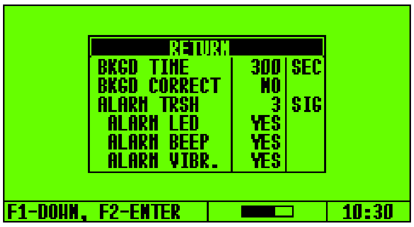

Figure 14: Submenu MEASUREMENT OPTIONS

To select an item, press the F1 button and, to confirm the choice, press the F2 button.

The duration of the background count rate measurement in the BACKGROUND mode is specified by the option "BKGD TIME" and takes on the values 100, 200, 300, 500, and 1000 s. Note, that at normal background conditions the background count rate is 0.1 - 0.3 cps. Therefore, to get a sufficient statistical accuracy of the data the minimum duration 300 sec should be applied.

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The “BKGD CORRECT” option is YES/NO. It decides whether a correction of the average background value (measured in the BACKGROUND mode) takes place in the SEARCH mode depending on the current count rate. In order to avoid a variation of the average background count rate when approaching a neutron source, this correction does not take place in case the current count rate exceeds the alarm threshold.

The “ALARM TRSH” (sigma multiplier) parameter directly reflects the probability of a detection and the false alarm rate, because it sets the alarm threshold. This value is given in multiples of the background standard deviation and varies from 1 to 6.

“ALARM LED”, “ALARM BEEP”, and “ALARM VIBR.” options activate / deactivate the corresponding alarm indicators. The options are YES or NO.

3.3 Shut down

A shutdown is possible in any operation mode. To turn off the device press the ⏻-button and keep it pressed until the shutdown-bar reaches 100%.

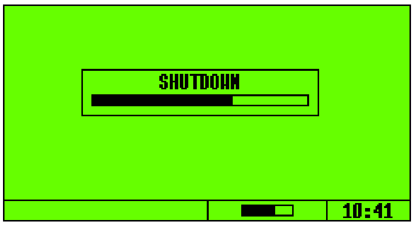

Figure 15: Switching the instrument OFF

A screen message appears asking if the shutdown is intended. Press the F1 and the F2 button successively to select “YES”. Selecting “NO” instead returns the detector into the current operation mode with all data being retained.

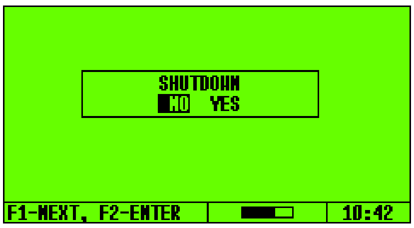

Figure 16: Shutdown menu

A shutdown will automatically clear the current measurement data. Only the list of alarm events (see 3.2.1) will remain in the detector’s memory and can later be read out via a PC.

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4 General recommendations

- In the SEARCH or the INTEGRAL mode the detector's bottom should face the object. The most sensitive point of the instrument is marked with a cross on its bottom. The reference point for gamma ray dose rate measurement is also marked with a cross and located on the top side of the instrument.
- On search and localization of a neutron source in the SEARCH mode it is recommended to take into consideration that the detector's detected minimum neutron intensity usually is proportional to:
    - the square of the distance between the source and the detector,
    - the square root of the background flux density,
    - the square root of the sweeping speed relative to the neutron source.
- A neutron source can be localized by the visual display indications and by the pitch of the acoustic alarm signal.

5 Battery charging

Make sure that the remaining battery's capacity is sufficient for the required time of operation. To charge the detector's batteries use the ACS410 Treveller provided in the delivery set. The charger operates at AC 100-240 V/ 50-60 Hz.

Connect the charger to the chassis connector, marked as "charger" and located under the protective cover on the left side of the detector case. The charger starts operation automatically as soon as the detector's batteries are connected to the Charger connector. During the test phase, which usually takes about 10 s (red LED is flashing) the charger analyses the batteries' condition and defines the number of cells. The charge procedure should follow the complete discharging. When the red LED switches over to a permanent light for charging, press the yellow button for about 2 seconds for discharging the batteries. After discharging, which may take several hours, the charger automatically switches to charging. After the charging procedure, the charger switches automatically over to trickle charge (green LED is on, red LED is off).

Under normal conditions of 20 °C the battery lifetime is about 8 hours. In a colder environment the battery lifetime decreases.

The recharging of the battery takes about 14 hours.

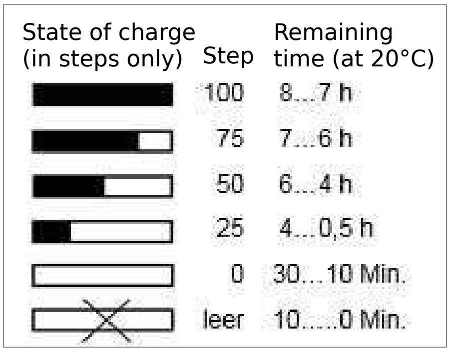

Figure 17: State of charge of the NiMH-battery

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6 Safety regulations

The detector is dangerous as it is a high voltage source. Thus, it is strictly prohibited to open the detector case when the detector is on.

Metal parts of the detector are designed in accordance with the safety standards/safety code/emergency decree for electrical installation with voltage above 1000 V. The casing is made out of nonconductive polycarbonate.

E.4. Portal Monitor

RADIATION MONITORING SYSTEM

FHT 1378

OPERATING MANUAL

1

Table of contents

1 Overview

The mobile radiation portal monitor system FHT 1378 is a modular, battery-powered measurement system for the detection of gamma- and neutron-radiation. It measures the counting rates of both gamma and neutrons which are then displayed in real time on a linked computer. Additionally, alarm lights on top of the detector case start flashing in case the pre-set alarm threshold is exceeded.
The radiation portal monitors can either be used with one column only as a stand-alone system or as a combined measurement system with two (or three) identical columns.

Figure 1: typical set-up of two radiation portal monitor columns

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2 Components

The FHT 1378 Radiation Portal Monitor (RPM) system consists of the following components:

- tripod
- a rechargeable lead-acid battery (battery runtime > 200h)
- gauging cylinder with
  - 6 litres plastic scintillator for gamma detection
  - He^3-proportional counter
- an antenna for the wireless signal transfer to a linked computer
- two warning lamps – blue for neutrons, red for gammas

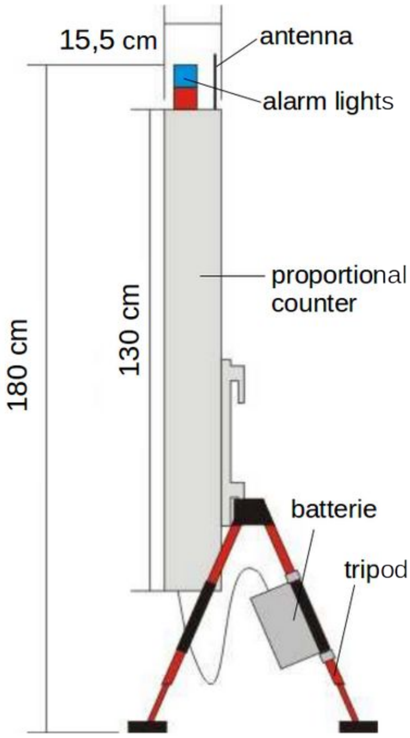

Figure 2: dimensions of the radiation portal monitor

2.1 Neutron Detector

The neutron detector is a He^3-proportional counter with an active height of 81 cm, a diameter of about 5.1 cm and a filling pressure of 2.5 bar. It is approved for the temperature range between -10 °C to 40 °C and has a sensitivity (for Cf-252) of 120 cps/(µSv/h).

2.2 Gamma Detector

The gamma detector consists of a plastic scintillator with a volume of 6 litres and has the dimensions 100 x 12 x 5 cm. It has an active length of 100 cm, an active thickness of 5 cm and is approved for the temperature range between

-10 °C to 40 °C. For Cs-137 the detector shows a sensitivity of about 35 000 cps /(µSv/h).

2.3 Detector Casing

The detector casing contains both the gamma and the neutron detector as well as the appendant electronics. It can be mounted onto the tripod and has an electrical outlet on the bottom to connect the detectors with the battery, which is also mounted on the tripod. The detector casing is made of aluminium, has a height of about 130 cm, a diameter of 15.5 cm and weights about 20 kg. It is dust tight and protected against water with protective class IP 65.

Figure 3: radiation portal monitor shown from the side

3 Operating the Radiation Monitor System

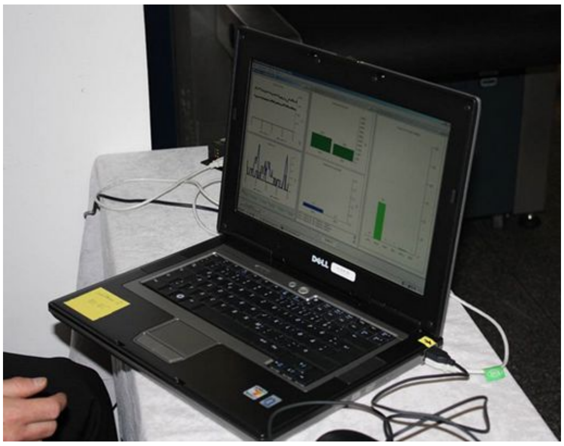

Figure 4: measured data shown on the screen of the linked computer

When in operation the radiation portal monitors run continuously and send real-time data of their measurements to a linked computer via radio transmission. In general, it would then be possible to collect and save the measured data on the computers hard-drive but in the given configuration this option is not in use. The data measured and transferred consists of both the gamma and the neutron count rate. The values are averaged over 5 seconds and the computer's display shows the time curves for both gamma and neutron over the last 30 s. With the given detectors no spectral analysis is possible since the radiation's energy is not measured.

4 Distance Dependency of the Neutron Count Rate

To get an idea of the signal's distance dependency, Figure 5 displays the result of a test measurement. The neutron count rate is plotted against the distance of a radioactive sample to the detector for two different portal monitor columns. RPM-93 and RPM-95 are the two columns of the combined RPM system. For the measurement a Cf-252 source (~6000 n/s) was used which equals the activity of about 50 g of unshielded weapons-grade plutonium (5% Pu-240).

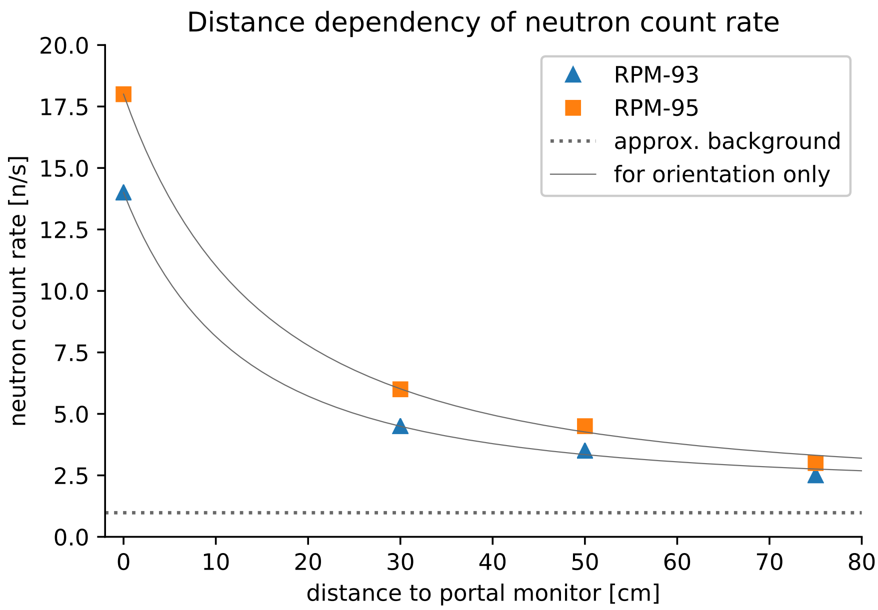

Figure 5: test measurement

In this test measurement the Cf-252 sample was on a level with the centre of the RPM columns where the detector's sensitivity is at its highest. Putting the Cf-252 sample on the ground while keeping the same distance to the detector, led to a drop in count rate by about a third.

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E.5. CCTV

CCTV Manual

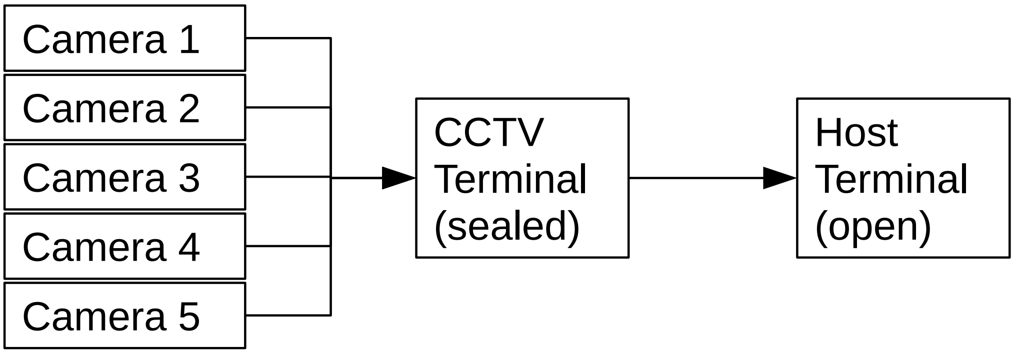
1

Function

This CCTV system is tailored to the requirements of a nuclear dismantlement inspection, providing the inspectors with trusted footage while giving the inspected party the resort of holding back footage if required for security reasons.

This is achieved by providing two terminal computers, one of which (the CCTV Terminal) is handling the footage, and another (the Host Terminal) can be used by the host party to view a copy of the footage without having access to the actual footage on the CCTV Terminal. To this effect, the CCTV Terminal is sealed after setting up the cameras.

This diagram shows the flow of the footage data:



Consequently, both terminal computers hold a complete copy of the footage.

The host party has access to the Host Terminal and can copy and check the footage for security or proliferation concerns at any time. This does not affect the data within the CCTV Terminal, it is configured so that it cannot be manipulated via the Host Terminal.

The data on the CCTV Terminal is intended for the inspectors. Whenever requested, and if the host party has no issue with the footage, the teams will jointly access the CCTV Terminal, copy the data onto an SD card, and transfer it to the inspectors using the according procedures.

Terminal computer handling

The terminal computers run a minimal Linux distribution and use simple scripts based on free software, to allow for authentication of the equipment and software if required.

The desktop is navigated much like a Microsoft Windows PC. After starting the computer, a command terminal window and a file browser window automatically appear. The windows can be moved by clicking and holding the mouse cursor on their title bar. By clicking on a window, the window is highlighted and can be worked with, e.g. commands can be entered into the command terminal window.

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Entering commands into the command terminal window is the primary method user interaction. Commands are case sensitive and have to be confirmed using the "↵Enter" key. Always enter commands completely, including the preceding "." and "/". A running command will occupy the command terminal window, but can be halted using the "Ctrl-C" key combination.

Setup

The following steps are required to set up the camera system.

1. Connect the terminal laptops to power. Connect CCTV Terminal to Host Terminal using the enclosed LAN cable.
2. Switch on the terminals. Wait for the desktop to appear.
3. On the CCTV Terminal, run the following command in the command terminal window:
   `./init_terminal.sh`
   Wait until successful.
4. For each CCTV camera:
   a) Attach enclosed antenna to CCTV camera.
   b) Transport the camera and enclosed power adapter to the deployment site.
   c) Connect CCTV camera to power using the enclosed power adapter. Attach the camera to the assigned spot.
   d) Wait for 30 seconds for the camera to connect. On CCTV Terminal, run the following command in the command terminal window:
   `./check_cctv#.sh`
   …where "#" is the number of the camera (from 1 to 5). A window will pop up showing the CCTV picture. Verify the camera is working and covering the desired area. Then close the window by clicking the closing button or by pressing "q".
   e) Repeat until all cameras are installed.
5. To check whether the installation is working, on CCTV Terminal, run the following command in the command terminal window:
   `./check_connections.py`
   An output in the command terminal window will report which connections are present. Check the results for missing connections; if any, repeat the setup for the mentioned camera or terminal.
6. If all cameras and Host Terminal are connected, on CCTV Terminal, run the following command in the command terminal window:
   `./init_cctv.sh`
   Shortly, a window should appear showing the output of all 5 CCTV cameras.
7. On the Host Terminal, run the following command:
   `./init_host_cctv.sh`

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Shortly, a window should appear showing the output of all 5 CCTV cameras. If this does not happen after a minute, restart the procedure by pressing “Ctrl-C” and re-entering the command.

8. If everything is satisfactory, close and seal the CCTV Terminal computer.

Operation

The CCTV system will run continually without intervention.

On both CCTV Terminal and Host Terminal, the footage will be saved in the “NuDiVe_footage” folder that is already open on the desktop. To facilitate navigation and handling, a new video file will be opened every full hour.

Whenever desired, the host team may access the footage from the Host Terminal by copying it on an SD card and checking it on their own computers.

When the inspectors request access, the CCTV Terminal has to be jointly opened and the data copied and handed over to the inspectors using the Data Transfer procedures.

Data transfer

The data transfer is conducted according to the procedure descriptions. Technically, the following steps are required:

1. Jointly open the CCTV Terminal.
2. Insert an SD card into the slot. Wait for a file manager window to appear.
3. Using the mouse, drag the footage to be transferred from the “Nudive_footage” folder to the SD card folder. Wait for the copying to finish.
4. Eject the SD card. This can be done either by looking for the SD card entry in the lefthand pane of the file manager window, and clicking the eject icon. Or it can be done by right clicking the SD card icon on the launcher, to the very left of the screen, and clicking “eject”. Wait for successful ejection.
5. Remove the SD card and transfer according to procedure.

Conflict resolution

If, to facilitate a conflict resolution, the host and inspectors jointly decide to delete part of the footage before it is handed over to inspectors, this can be done as follows:

1. The host should determine the exact time and video file of the material that is to be cut.
2. Jointly unseal and open the CCTV Terminal.
3. Verify that the footage file to be edited is not currently being written to. This is the case if the footage is not from the current full hour.

4

4. On the CCTV Terminal, run the following command in the command terminal window:[1]
   `./cctv_cut.py -b BEGINNING -e END -c CAMERAS FILENAME`
   - Supplement the following information:
     - BEGINNING is the starting time of the compromising footage, counted from the start of the video.
       (The format is "hours:minutes:seconds.deciseconds", e.g. "`-b 00:11:22.3`")
     - END is the end time of the compromising footage, counted from the start of the video.
       (The format is "hours:minutes:seconds.deciseconds", e.g. "`-e 00:11:22.3`")
     - CAMERAS is the list of cameras whose picture should be removed.
       (The format is just the camera numbers, e.g. "`-c 135`")
     - FILENAME is the name of the video file, entering the full path is not required
   - The "-b" and/or "-e" parameters can be left out. In this case, the deletion will start at the beginning/finish at the end of the video file.
   - (Example command:
     `./cctv_cut.py -b 00:15:00.0 -e 00:20:00.0 -c 135 NuDiVe_2019-09-05_12-00-00`)
     This will delete the footage from minute 15 to minute 20 from cameras 1, 3 and 5.)
   - After a few minutes[2] the redacted video file will appear in place of the original file, and have the ending "_redacted.mkv".

Shutdown

To shut down the terminals, simply select all running command terminal windows and halt the footage recording using the "Ctrl-C" key combination. Afterwards, press each terminal's power button and click "Shut Down" in the appearing window.

1 The host team can check the result of this command beforehand on their own computer. By adding the parameter "--keep" to the command, the original footage is retained, and the redacted footage will copied to a new file. (Example command: "`./cctv_cut.py -b 00:15:00.0 -e 00:20:00.0 -c 135 –keep NuDiVe_2019-09-05_12-00-00`")

2 The exact time depends on the amount and complexity of footage to be deleted. Normally, it takes about 10 seconds per minute deleted.

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F. Training

F.1. Training schedule

Mon	Host	Insp		Tue	Host	Insp
09:00:00	Arrival	Arrival		09:00:00	Arrival	Arrival
09:15:00	Welcome	Welcome		09:15:00	Portal Monitor and neutron monitor: Briefing, familiarisation [GK, BfS]	Work on inspection plan
09:30:00	Host Introduction [IN, …]	Inspector Introduction [GK, …]		09:30:00		
09:45:00				09:45:00		
10:00:00	Behavioural rules [AQ]	Sealing: Briefing, familiarisation [SH]		10:00:00		
10:15:00				10:15:00		
10:30:00	Safety briefing [IN, Rad.prot.]			10:30:00		
10:45:00		Break		10:45:00	Entry: Briefing, familiarisation [IN, Rad.prot.]	
11:00:00	Break	CCTV: Briefing, familiarisation [SH]		11:00:00		Portal Monitor and neutron monitor: briefing, familiarisation [GK, BfS]
11:15:00	Transfer			11:15:00	2nd site visit	
11:30:00	1st site visit [IN]	Behavioural rules [AQ]		11:30:00		
11:45:00				11:45:00		
12:00:00		Lunch		12:00:00		
12:15:00				12:15:00	Lunch	Lunch
12:30:00	Lunch			12:30:00		
12:45:00				12:45:00		
13:00:00		Gamma monitor: briefing and familiarisation [GK]		13:00:00		
13:15:00				13:15:00		
13:30:00				13:30:00	**Start of Inspection**	
13:45:00	Sealing: Briefing, familiarisation [SH]			13:45:00	First Host-Inspector Meeting: Welcome	
14:00:00		Safety briefing [IN, Rad.prot.]		14:00:00	Host Site Briefing for Inspectors	
14:15:00	CCTV: briefing, familiarisation [SH]			14:15:00		
14:30:00		Break		14:30:00	Inspection Plan Briefing for Host	
14:45:00	Break	Work on inspection plan		14:45:00		
15:00:00	Gamma Monitor: briefing and familiarisation [GK]			15:00:00	Negotiation, familiarisation visits and breaks as teams see fit	
15:15:00				15:15:00		
15:30:00				15:30:00		
15:45:00				15:45:00		
16:00:00	Prepare Site Briefing			16:00:00		
16:15:00				16:15:00		
16:30:00				16:30:00	Team Meeting	Team Meeting

G. Equipment lists

G.1. Equipment in general container

NuDiVe Inspection 2019, 23–27 Sep

Items inside: General equipment box

Item	Tag
Photo Camera 1	0003543
Photo Camera 2	0003542
6x blank SD cards (2 inside cameras)	—
6x secure vial	—
5x micro SD card	—
2x charge cable for cameras	—
Seals	0003535
2x reflective particle	—
Laser distance meter	0003541
Tape measure	0003540

G.2. Equipment in CCTV containers

NuDiVe Inspection 2019, 23–27 Sep

Items inside: CCTV box

Item	Tag
CCTV Camera 1	0003548
CCTV Camera 2	0003547
CCTV Camera 3	0003545
CCTV Camera 4	0003546
CCTV Camera 5	0003544
CCTV Terminal	0003550
CCTV Host Terminal	0003549
2x Hex key	
1x Network cable (yellow)	
2x laptop‘s power supply	
5x CCTV camera’s power supply	

G.3. Equipment in detector containers

NuDiVe Inspection 2019, 23–27 Sep

Items inside: Detector boxes

Item	Tag
Gamma detector 1	0003539
Gamma detector 2	0003538
Neutron detector 1	0003537
Neutron detector 2	0003536
Portal Monitor RPM 3/97	0003423
Portal Monitor RPM 2-93	0003422
Portal Laptop RPM2-93/95	0003429
Portal Laptop RPM3 96/97	0003428
Portal Battery 1	0003427
Portal Battery 2	0003426
Portal Battery 3	0003425
Portal Battery 4	0003424

G.4. Test sources

NuDiVe Inspection 2019, 23–27 Sep

Items: Test Sources

Item	Tag
Gamma test source	0003399
Neutron test source	0003398

H. Briefing documents

H.1. Behavioural rules

NuDiVe
Nuclear Disarmament
Verification

The NuDiVe Exercise

The German-French Exercise for the International Partnership for Nuclear Disarmament Verification's Phase II

Behavioural Rules during the NuDiVe Inspection

Out of game

The NuDiVe exercise is a simulation exercise, not a real inspection in an actual weapons facility. Inherently, participants will have to differentiate between what is part of the simulation, i.e. “in-game”, and what is not.

To facilitate this, as a general rule, **people and items clearly marked in a green colour are out-of-game and should be ignored by the participants** and not treated as part of the exercise’s simulated reality.

For example, people wearing green coats or jerseys should not be addressed and treated as not present by the participants. This is usually the case for evaluators and observers, guests or organisers. Notably, **all people not marked in green should be treated as part of the exercise.**

Items or structural features covered by green tape should also be ignored or treated as if they were ordinary parts of the dismantlement facility. The most important examples are the windows of the dismantlement room, which can be ignored for the exercise and treated as a wall that is not subject to investigation. Also, the whole upper part of the dismantlement room including the ceiling are out-of-game.

Colour codes

All participants are easily identified by their primary clothing colour:

- **Inspectors** wear black NuDive shirts and, in the radiation protection area, white protective overalls.
- **Host** personnel wear red NuDiVe shirts and lab coats.
- **Host Technical** personnel wear blue NuDiVe shirts and lab coats.
- **Evaluators and observers** wear green NuDiVe shirts and lab coats. As such they are marked out-of-game.

General Rules

All communication should occur in an orderly fashion and along team hierarchies. During the inspection, Inspectors can communicate with Host team members in order to conduct the procedures, but if any questions or discussions arise, the Team Leaders should be involved or informed as soon as possible, to keep everyone on the same page and avoid inconsistencies.

All actions should be announced clearly in advance during the inspection. This avoids confusion and actions which compromise the inspection integrity.

Inspectors

Inspectors have to be accompanied and watched by a Host guard at all times, except for the Inspector’s Room and in the rest rooms.

The Inspectors can address the Host team members (red) with questions, but they should avoid talking to the Host Technical personnel (blue).

Within the radiation protection area, Inspectors have to wear protective suits and must avoid touching anything that is not explicitly handed to them.

Each day, upon entering the Dismantlement Building, Inspectors have to hand over their personal phones and other electronics. Computers will be available in the Inspector's Room.

Data (notes, footage, pictures) collected during the inspection can be accessed and evaluated within the Inspector's Room, but is not to be taken off site.

Host Personnel

Inspectors must always be watched by at least one member of the Host team. It is sufficient if a member of the Host Technical personnel does this.

Host Technical personnel are also organisers. When questions arise, the Host team members can always address them as such. However, the preferable path of communication always goes by the Team Leader.

Radiation protection area (controlled area)

The inspection will be conducted in the controlled area. Before entering the controlled area for the first time, you will get a radiation protection instruction by a local radiation protection officer.

Visitors must be escorted by a local radiation protection officer or an experienced scientist from IEK-6. It is essential to follow the instructions of these escorts. They are to be informed immediately in case of problems or incidents.

Host personnel and Host Technical personnel will enter the controlled area on the upper floor, Inspectors and Evaluators on the ground level.

Host personnel, Host Technical personnel and Evaluators will get a lab coat, Inspectors will be dressed by the Host personnel with protective suits, gloves and overshoes.

Before entering the controlled area, you are required to check your hands and shoes for contamination by the hand and foot monitor.

You cannot see, smell, or feel radiation, but you can measure it. You will therefore receive a dosimeter that you must wear at a part of the body that can be considered representative for radiation exposure, usually on the front part of the trunk (front pocket of the coat). It is prohibited to enter the controlled area without a dosimeter.

In the controlled area, it is generally forbidden to eat, drink, smoke or make-up in order to exclude incorporation of radioactive substances as much as possible. With open wounds you are not allowed to enter these areas. Pregnant and nursing women are not allowed to enter these areas either.

When leaving the controlled area, you are required to check again your hands and shoes for by the hand and foot monitor to avoid the carryover of radioactive substances.

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Evaluators and observers

First and foremost, evaluators and observers should try not to obstruct or interfere with the ongoing simulation. This can be achieved by following a few simple rules.

Evaluators and observers should keep quiet and not communicate with in-game participants. When no Host (red) or Inspector (white coat/black shirt) participants are present, it is ok to talk to organisers (blue).

In-game personnel always have priority when moving about, so the evaluators and observers should stay back and not obstruct their paths. Within the facility rooms, preferable observation spots are marked in green.

The facility rooms are small and easily crowded, so evaluators and observers should only enter them if there is enough space. As a rule of thumb, the number of evaluators and observers should not exceed 2 per room.

Evaluators and observers may enter the radiation protection area either using the upper floor entrance (which is for Host and Organisers) or using the ground floor entrance (which is for Inspectors), depending on queues.

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H.2. Recommendations to team leaders

NuDiVe
Nuclear Disarmament Verification

The NuDiVe Exercise

The German-French Exercise for the International Partnership for Nuclear Disarmament Verification's Phase II

Recommendations to Team Leaders of the NuDiVe Exercise

1

Inspection approach

The NuDiVe exercise has been conceived in a flexible way. The general scenario of inspection is defined in 18 detailed steps, and implemented through inspection procedures. However, the way for inspectors and hosts to implement those steps was not made in a prescriptive way. Two approaches seem to be possible from a team management point of view, in order for participants to agree on an inspection plan :

- A "comprehensive" approach, in which every member of the team is able to perform any type of procedure needed for the scenario.
    - *Pro : This approach allows more flexibility in case of unexpected events or unavailability of one or several team members*
    - *Con : This approach may not be the most efficient in term of training time spent for all team members to be competent on all activities, equipment and technologies. Due to room constraints in Jülich, no more than two or three inspectors can be present in the radiation protected area at a time.*
- A "specialised" approach in which teams are divided into sub-groups specialised in specific activities (i.e measurement, sealing, data monitoring, reporting…)
    - *Pro :*
      Sub-groups can be more focused on their speciality and keep a deeper knowledge of their issue along the exercise. As most of the procedures are only conducted once or twice individual inspectors will only participate in some activities anyway, but not in all.
    - *Con : This approach may require more coordination and team management. A segmented knowledge may also hamper comprehensive vision for final reporting activities.*

From the organisers point of view, the specialised approach seems to be more suited for the NuDiVe exercise type, as it may be more appropriate to tackle efficiently time constraints.

Considering the chosen management strategy, **trainings** on day 1 and 2 of the exercise could be adapted to fit with "specialised" sub-teams.

Team interactions

In the way the exercise was constructed, two natural interactions seem to appear in order to reach the final objectives

- **Inspection team – Host team** : These two teams will be in direct interaction during the implementation of inspection tasks, but also in planning discussion. It seems necessary to engage a close dialogue between the two teams, as many elements will be subject to negotiation: inspection strategy, final inspection report, dispute settlement modalities…
  A room for these negotiations will be provided.
- **Evaluation Team – Organisers** : The evaluators are "off-game", and should not interact with hosts and inspectors during the exercise. However, as the role of evaluator is to assess the general value of the exercise, it seems natural that a critical discussion occurs between the

evaluators and organisers *before* the exercise (preparation, evaluation strategy and criteria), *during* the exercise ("hot" remarks during daily briefings), and *after* the exercise (drafting of evaluation report). Evaluators can address organisers at any time for clarification questions, or for complementary documents that would help them in their evaluation task.

For the purpose of the Evaluation, we can however imagine that Evaluators could be able to join and observe internal team meetings (such as evening working dinners), and to discuss with Host and Inspection team leaders at the end of the exercise (NOT in-game).

Inspection practicalities (to Inspection and Host Teams)

- As the NuDiVe framework defines that this inspection is the first of many within the Treaty context, both governments are highly interested politically in its process. Thus, **both host and inspection team leaders shall provide a daily summary report to their respective government** (email addresses will be provided).
- Inspection procedures, even though all written on the same basis and format, differ in their respective goals. Inspectors may want to develop a specific way to report information gathered during an inspection procedure through **specialised inspection notebooks**.
- **To inspectors, light clothes** are encouraged to allow more comfort inside the inspection suits.
- **Communication technology** (hardwire phones) between inspectors within the radiation protection zone and those outside will be provided in order for them to get feedback from their HoD.

General remarks (to all teams)

- We encourage Team Leaders to **remind their teams to read documents** at their disposal prior to the exercise
- **Paper copies** of all necessary documentation (notably procedures), will be made available upon arrival of the participants

H.3. Detailed briefing

The NuDiVe Exercise

The German-French IPNDV Exercise for the International Partnership for *Disarmament Verification's Phase II*

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Goal

The exercise concentrates on the verification of nuclear disarmament. It will focus on the technologies and procedures providing sufficient confidence about the absence of diversion of nuclear materials during the dismantlement operation of a nuclear warhead within a treaty-related disarmament regime. The aim will be to assess how the chain of custody can be maintained during and after the dismantlement step in a way that strengthens the confidence and effectiveness of a nuclear disarmament verification regime. Beyond its technical interest, it is intended to share the experience between non-nuclear weapons states (NNWS) and nuclear weapon states (NWS).

Scope

The exercise is part of Step 8 of the International Partnership for Nuclear Disarmament Verification (IPNDV) Dismantlement Process ("Nuclear Weapon Dismantlement" - see Figure 1). As it will take place in the radiochemical laboratories of the Jülich Research Center in Germany, the exercise will focus on a step 8.2 which excludes manipulation of high explosives (HE) and therefore excludes the need of a pyrotechnical adapted building. It will be assumed that the separation of HE from the treaty accountable item (TAI) would have occurred directly before the exercise in step 8.1.

The initial step 8 figure used during IPNDV phase 1 walkthrough exercise is adapted in this exercise such that HE dismantlement is explicitly made separate from the other dismantlement activities in step 8.Figure 2 is a general schematic diagram of the dismantlement phases 8.1 and 8.2.

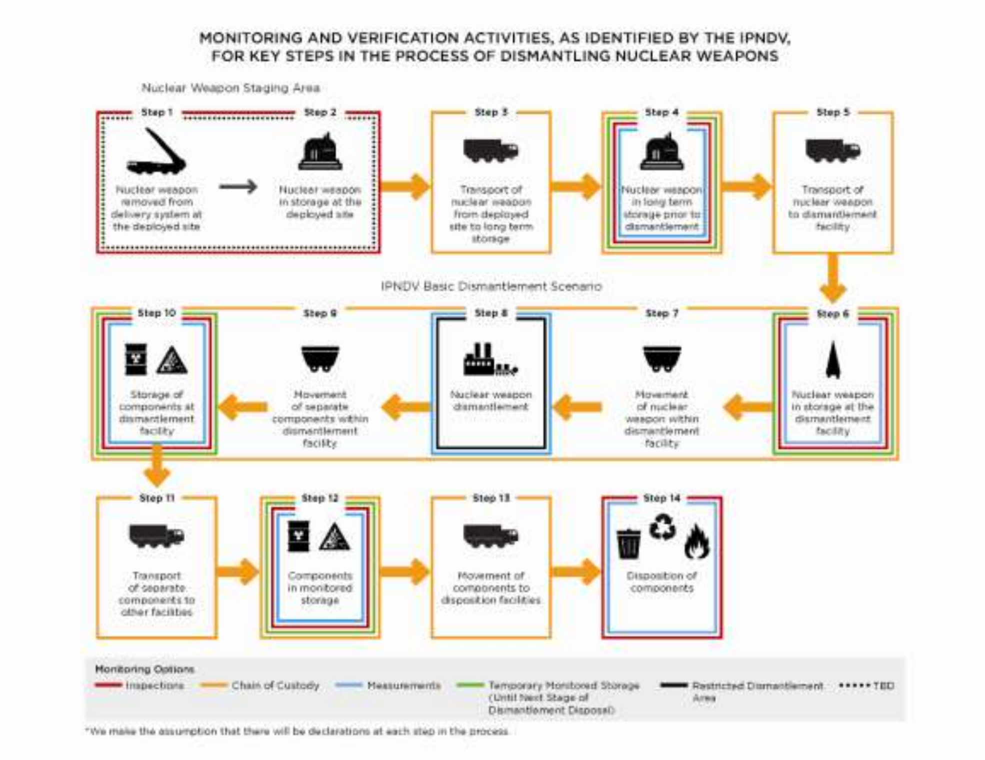

Figure 1: IPNDV Key steps in the process of dismantling nuclear weapons

The exercise will take place in a simulated special nuclear material (SNM) dismantlement building that will contain a simulated Dismantlement Station (DS) and start with a control of the facility by inspectors. Afterwards, a box of SNM/Other Components (SNM/OC) will be present in the dismantlement building whereby the identity and integrity of the SNM/OC is assumed to be already been partially checked. The exercise sequence will include:

1. Introduction to the NuDiVe exercise, which includes training and preparations

2. Stepwise procedures of the Inspection scenario

3. Reporting and discussion

The sequence is described in detail in the Dismantling Steps section below.

3

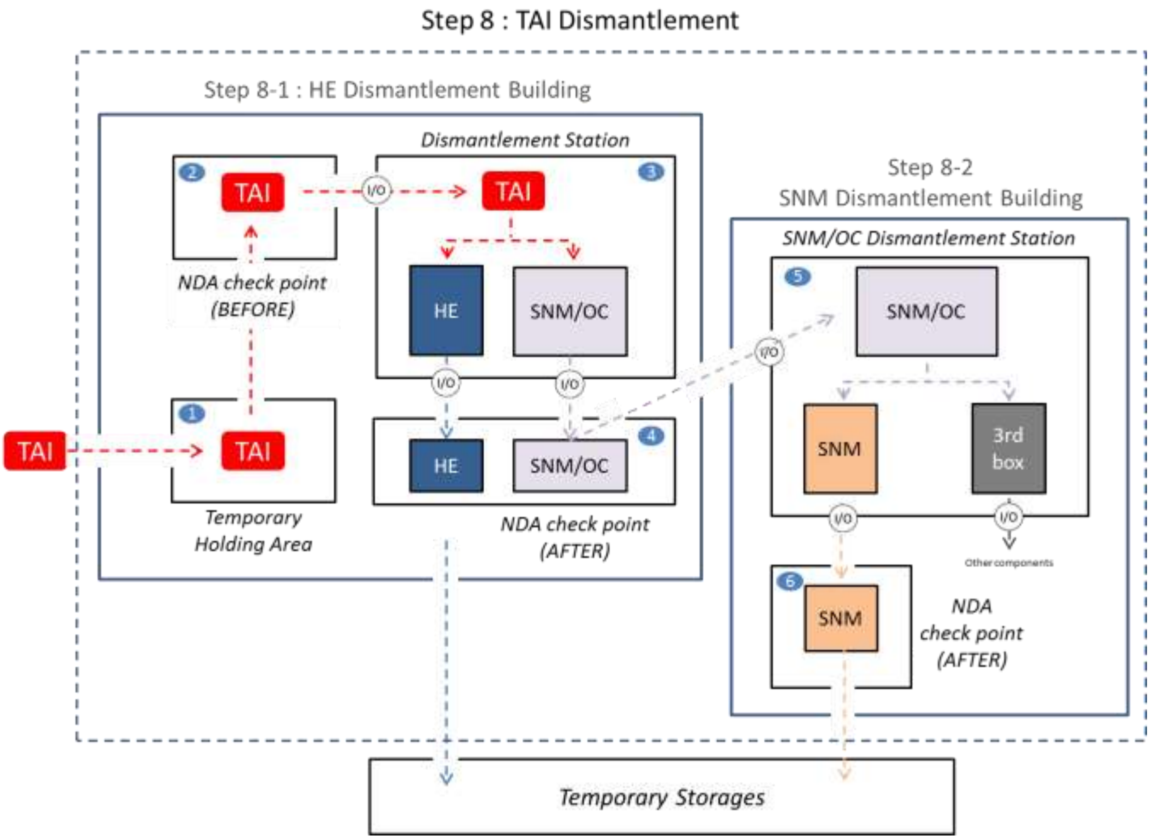

Figure 2: Schematic Diagram of Dismantlement Phase

The NuDiVe exercise scope is laid out to avoid duplicating efforts which have been demonstrated satisfactorily in other exercises (such as the UK-Norway Initiative[1] or the QUAD Letterpress[2]). Consequently, the following aspects are NOT simulated, but may be included to expand the scope of the exercise:

- The identification, seal check and sealing of the containers as they arrive and leave the dismantlement site.
- The sealing of containers after performing a successful absence measurement.
- The use of an information barrier (IB) to check the containers at the non-destructive assay (NDA) check point before and after the dismantlement process, to confirm the location of the SNM.

[1] https://ukni.info/
[2] https://thedefensepost.com/2017/10/25/nuclear-disarmament-verification-exercise-letterpress/

4

Participants

Participants will be divided into three teams for the duration of the exercise based on their role within the exercise. These teams are described below. Most participants are expected to be experts from the IPNDV Phase II working groups. At both 2018 IPNDV working Group meetings in Stockholm, Sweden and Seoul, South Korea, an announcement was made to the working groups about this exercise. Annex 2 of this document lists experts who have indicated that they are interested in assisting in the preparation (procedures writing and technology implementation) and execution of this exercise. In due time, a call will be announced to the IPNDV working groups asking for voluntary participation in the exercise. Once the selection of participants (according to their expertise and nationality) is made, each participant will be assigned to a team. Each team will take on specific responsibilities for preparing for the exercise based on the role of their respective team.

1. Inspection Team
   Before the exercise commences, the inspection team will need basic knowledge in the principles of the inspection strategy and the technologies used in the exercise. Inspectors may implement equipment only in accordance with the regulations of the host country.
2. Host Team
   The host team will be trained in advance to be familiar with all safety and security procedures of the facility. They should also be familiar with all measurement equipment utilised. The operational work within the exercise will be carried out by a qualified operator from the host country. The exercise organisers will be included in this team and will oversee the exercise. They will act as experts and answer any questions from the other teams.
3. Observation Team
   The observation team will not be responsible for any prior knowledge of the exercise. The role of this team is to observe the exercise, gain knowledge about inspection activities and contribute to the findings and evaluation of the exercise.

A training course will prepare the inspector and host teams on the use of specific equipment (software and hardware) used during the exercise. All participants will be expected to meet the health and safety requirements to enter the radiation protection zone according the facility's rules and regulations as well as specific rules set forth by the host team. Each team should include at least one member from a nuclear weapon states (NWS) and members from non-nuclear weapon states (NNWS) from different geographic areas of the world in order to obtain a global perspective on each team's experience. During the exercise, each team will act within their team's role.

Facilities

The exercise requires several rooms to accommodate carry out all the steps. Due to the restrictions of working within a radiation protection zone, when possible, meeting rooms will be located outside of the radiation protection zone but within the same building.

German Facility Regulations

For reasons related to fire safety and radiation protection regulations, the number of people at each workstation inside the laboratory (inspectors/hosts/observers) must be minimized. As a result, inspectors will have to divide tasks in agreement with the host country regulations. For example, each room has a maximum capacity of occupants so it is possible that only certain members of each team will be permitted to participate in a given activity since the room's maximum occupancy may be lower than the total number of participants in a team. In other words, it should not be expected that all participants from a team will be able to carry out each step in the exercise simultaneously. The inspection team will have to prepare and organize its inspection taking into account these regulations.

In their own interest and that of others, all persons entering the radiation protection zone are obliged to follow regulations in the Radiation Protection Instructions Annex to this document.

Host Team Facility Regulations

In addition to the German facility rules and regulations, all exercise participants must follow the rules and regulations set forth by the Host team. The Host team's rules and regulations must always be in accordance with the German facility regulations.

Inspection procedures

The inspection scope will be predetermined in order to confine the steps to meet the goals of the exercise. Below is a brief description of the inspection areas with general statements to be considered about each of the areas. The high explosives (HE), special nuclear material (SNM) and other material will be simulated with proxies. The SNM will be a surrogate radioisotope with similar gamma intensity of 50 grams of Plutonium. For more information about how the surrogate was selected, please see Annex 4.

Transportation to the dismantlement station

Transportation of the TAI to the dismantlement station will be monitored using a portal monitor and inspector presence (visual observation).

Dismantlement station

The dismantlement station (DS) will be the primary focus for the inspector team during the exercise. C/S and NDA equipment will be used in this area. The inspection team will need to ensure integrity of the DS and validate previous design information verification documentation by conducting visual inspections, sweeping, e.g. using gamma measurements, sealing of potential diversion paths, checking the integrity of seals/tags and monitoring the in and out of host people (bathroom, change of shifts). In this exercise, a multipurpose facility is simulated, necessitating the thorough inspection and sealing of the room.

Transportation out of the dismantlement station

Transportation of SNM/OC will be monitored using a portal monitor and inspector presence (visual observation).

Exercise Assumptions

Background information: The exercise takes place in Urania, a NPT signatory nuclear weapon State. In accordance with its obligations stemming from a separate multilateral nuclear disarmament treaty, Urania allows multilateral inspections to verify the different processes pertinent to the elimination of a number of nuclear warheads. This process takes fully into account the principle of non-proliferation and concerns related to national security. These inspections are implemented on the basis of an agreed verification arrangement, pursuant to the disarmament treaty.

Urania nuclear warhead dismantlement is implemented within a multipurpose campus in Jülich. This campus is also used for day-to-day nuclear weapons related activities (manufacturing, refurbishing). Within the frame of the treaty-related verification regime, an inspection process is to take place during step 8.2, when SNM are separated from other materials and packaged.

It is assumed that HE were previously separated from the TAI during step 8.1, implemented in a specific pyrotechnical building, and monitored by a specific verification process.

It is assumed that this inspection is the first of many others as provided for by the verification agreement. Relevant information has been previously provided to the inspecting team concerning the facility, equipments and technologies, procedures of inspection, in order for them to prepare.

Dismantling Steps

The following sequence of steps will be followed to demonstrate the goals described in the beginning of this paper. The grid boxes shaded with a light red background indicate that this step will not take place during the exercise. Some of the notes in this grid refer to specific stations from Figure 2.

Step	Title	Actions	Equipment	Notes
Step 8.1 HE-Facility No Treaty Accountable Item (TAI) in the facility				
1	Safety instructions			
2	Visit of the facility			
3	Commissioning of control equipment			
4	Dismantlement building check-up			
	Specific check -up of station 3			
Treaty Accountable Item (TAI) in the facility				
5	Arrival of the item to the facility			
6	TAI positioned in temporary storage area in station 1			
7	TAI positioned in NDA area (local 2)			

Step	Title	Actions	Equipment	Notes
8	Verification of station 3 (optional -in case Inspectors deem it necessary. E.g.: steps 5–6 have occurred and there has been a significant delay and/or change of inspection staff)			
9	TAI positioned in station 3 for separation of HE and SNM/Other components (OC)			
10	Break-up of seals			
11	Dismantlement operations by the host State			
12	Set up the chain of custody on the 2 containers : HE, SNM/OC			
13	HE container positioned to room 4 NDA			
14	HE container positioned to temporary storage area			
15	SNM/OC container positioned to room 4 NDA			
16	Specific check-up of room 3			

Step	Title	Actions	Equipment	Notes
Step 8.2 SNM-Facility No container (SNM/OC) in the facility				
17	Safety instructions	- Presentation of the facility - Presentation of the inspection team - Presentation of safety instructions - Presentation on inspection modus operandi (managed access)		-Briefings given outside the dismantlement building – What information is given? (to be defined) -Managed access in the working zone with pyrotechnical and radiation risks
18	Visit of the facility	- Familiarisation and visual check : identification of diversion paths	- Camera - Standard inspection suits	-Review general operating procedure including verification of pictures -I/O Memory card operating procedure -Training will explain camera verification and traceability -Tooling is shrouded
19	Commissioning of control equipment	- Set up of entries and exits control on the SNM-dismantlement room (room 5) to detect any radioactive material (or suspect transfer) from leaving or entering the room	- Portal monitors - CCTV - Standard inspection suits	- Information barrier on the portal if the technology requires it (spectrum) - Video reported outside the pyrotechnical zone, in accordance with the safety and security regulations in the host country - Portals commissioning procedure - CCTV commissioning procedure - I/O controls on local 5 operational until step 31
20	Dismantlement building check-up	-Screening of the SNM Dismantlement building (including room 5)	-γ-n measuring equipment	-Procedure for identifying measuring points to establish a reference - Focus on the screening to be discussed

Step	Title	Actions	Equipment	Notes
	Specific check -up of station 5	- Set up of seals on the potential diversion pathways of station 5	- Standard inspection suits - Clipboard - Inspection protocol - Camera - Adhesive Seals - Reflective particle matrix - Camera, - Memory card, - Secure Vial	-Sealing procedure (instruction, traceability) -I/O Memory card operating procedure
SNM/Other components Container in the facility				
21	Arrival of the item to the room 5 – (not simulated, implemented by the host team)			- The HE dismantlement building is empty - Containers (x2) for SNM and other components are in their temporary storage area
22	SNM/OC container positioned in its temporary storage area in station 5	- The container go across the portal monitor - Verify chain of custody (CoC) e.g. tags and seals / unique identifier	- Camera - Portal - Unique identifier - Tags and seals	-Container followed through CoC
23	Break-up of seals	-Break-up of seals on SNM/OC container	- Camera - Seals	-Container's seals break-up procedure (instructions, traceability) -The Inspectors withdraw and the "dismantlement" may commence
24	Dismantlement operations by the host State – not simulated, except	- Implementation of the components on dismantling tools	- Tooling - CCTV (entry)	- No inspector in the facility - Monitoring of I/O by CCTV in the

Step	Title	Actions	Equipment	Notes
	for shift changes	- Withdrawal of the SNM/OC container (empty) - Dismantlement - Dismantled components are separated and packed in two containers : SNM and OC (3rd box)	- Portal monitor (entry)	authorized zone. - Inspectors shift change is simulated (depends on IT strategy)
25	Set up the chain of custody on the 2 containers : SNM, OC	- Application of tags and seals on the 2 containers	- Clipboard, - Inspection protocol, - Camera, - Adhesive Seals, - Reflective particle matrix, - Camera, - Memory card, - Secure Vial,	- Sealing procedure (instruction, traceability)
		- Containers go across the portal monitor	- Portal	
26	SNM container positioned to room 6 Non-Destructive Analysis (NDA) (not simulated, implemented by the host team)	- Verify chain of custody (not implemented) - SNM detection	- SNM-measuring equipment	- Operating procedure - Container go across the portal monitor
27	SNM container positioned to temporary storage area (not simulated, implemented by the host team)			- Continuity of CoC
28	Container 3 (OC) positioned to area 6 (NDA) (not simulated, implemented by the host team)	- Verify chain of custody - SNM detection	- Measuring equipment	- Verification of the absence of SNM - Operating procedure - No TAI's components in the station 3
29	Container 3 (OC) positioned to	- Verify chain of custody		- Control of entries and exits of station 3

Step	Title	Actions	Equipment	Notes
	temporary storage area (not simulated, implemented by the host team)			- Continuity of CoC
30	Specific check -up of station 5	- Verify and withdrawal of the seals - Screening of station 5	-γ-measuring equipment -Visual observation -Seals -Camera - Memory card, - Secure Vial,	- Procedure for identifying measuring points for comparison with reference (step 20)
31	SNM-Dismantlement building check-up	- Screening of the SNM dismantlement building (including dismantlement station) and comparison with step 2 - Withdrawal of entries and exits control	- γ-measuring equipment	-Operating procedure -Procedure for identifying measuring points for comparison with reference (step 20)
32	HE-Dismantlement building check-up	- Screening of the dismantlement building (including dismantlement station) and comparison with step 4 - Withdrawal of entries and exits control	- γ-measuring equipment	-Operating procedure -Procedure for identifying measuring points for comparison with reference (step 4)

Schedule

There are two options listed in this section. Option 1 lasts five days and Option 2 lasts three days.

Option 1: Five Days

The exercise will be composed of a 2-day training workshop and a 3 day exercise. The 2-day training workshop will familiarize the Inspectors and Host groups on the methodologies and technologies used in the exercise. The 3-day exercise will include all participants and carry out the major activities of the exercise.

Training workshop

The training workshop will ensure that the Inspectors and Host teams will have enough background information to actively participate in their respective roles during the exercise.

Day 1: Technologies

The Inspectors and Host teams will be briefed on the capability and use of each technology used in the exercise.

Day 2: Methodologies

Once the technologies are understood by the participants, they will be trained on how to use the technologies for verification. This day will review what techniques are possible for each of the technologies.

Exercise

Day 3: Participants exercise pre-briefing

- Safety and security instructions by facility operator and host team
- Joint sessions and group sessions (inspectors/hosts)
- Review of training on measurement techniques
- Review of training on inspection procedures

Day 4: Inspection exercise

8:30 Arrival at site

Briefing between inspectors and host

- H: Safety and security instruction
- I: Inspection plan/activities
- I/H: Negotiations on inspection procedures

10:00 Enter 'dismantlement facility' (DF)

13:00 Lunch

14:30 Resume inspection exercise

17:00 End inspection exercise for Day 2

Morning of Day 5: Inspection exercise continued

8:30 Arrival at site

9:30 Continue inspection exercise

12:00 Conclude all inspection activities

12:30 Lunch

Wrap-up

13:30 Wrap-up

17:00 Conclude exercise

Option 2: Three Days

The exercise will be composed of a 1 day training workshop and 2 day exercise. The 1 day training workshop will familiarize the Inspector and Host groups on the methodologies and technologies used in the exercise. The 2 day exercise will include all participants and carry out the major activities of the exercise and conclude with a ½ day wrap-up session.

Training workshop

The training workshop will ensure that the Inspectors and Host teams will have enough background information to actively participate in their respective roles during the exercise.

Day 1: Technologies & Methodologies

The Inspectors and Host teams will be briefed on the capability and use of each technology used in the exercise.

Once the technologies are understood by the participants, they will be trained on how to use the technologies for verification. This day will review what techniques are possible for each of the technologies.

Participants exercise pre-briefing

- Safety and security instructions by facility operator and host team
- Joint sessions and group sessions (inspectors/hosts)
- Review of training on measurement techniques
- Review of training on inspection procedures

Exercise

Day 2 & 3:

Inspection exercise

Wrap-up

Technologies

The IPNDV Walkthrough Exercise has highlighted a number of options regarding verification technologies applicable to this exercise. Technology sheets detailing suitable equipment are also available. In general, the following is required to aid in the verification of Step 8:

- Absence measurement (gamma, neutron)
- Portal monitor (gamma, neutron)
- Adhesive seals

I. In-game documents by participants

I.1. Daily reports by the inspectors

Report to Inspectorate HQ by Inspection Team Urania
2019.09.23

The first day at Jülich Forschungszentrum went generally well.

Introduction program was followed.

Unfortunately, despite two requests (at lunch time and via telephone) the Host Team Leader would not allow the Team to familiarize with the facility. This hampered seriously the understanding of the Team of the actual situation. Our preparation and planning were hampered.

The computers in our inspection room could not be stored and sealed as usual. At the end of the day, this still had to be resolved.

Report to Inspectorate HQ by Inspection Team Urania
2019.09.24

The second day at Jülich Forschungszentrum started with the procedure of storing and sealing of computers. It was agreed that our computers and other items in our room will be treated as safe and secure.

Introduction program was followed.

Familiarization with the facility took place in the early afternoon. The Team was on the basis of the actual situation able to eliminate unnecessary activities from the inspection plan that was conceptualized on the first day.

Several open questions remained. These were addressed in the end-of-day meeting with the Host Team. Not all issues could be resolved immediately; these will be addressed tomorrow. A list of issues will be in the Final Inspection Report.

Report to Inspectorate HQ by Inspection Team Urania
2019.09.25

In the morning, the first meeting between the Team Leaders of both the Host and the Inspection Team took place, each accompanied by a team member. All issues but one addressed the evening before were agreed by the Host. The issue of sharing event logfiles of the portal monitor remained open. The Host did agree with verbally sharing the events; he said that he would come back on the sharing of the complete event logfiles. In the concluding meeting at the end of the day, the Host Team Leader agreed with sharing the event logfiles.

After this morning meeting, the Team started with practical work.

Procedures 3 and 7

It was decided that it would be more efficient to have three rather than two inspectors for this task. Otherwise multiple sealing and subsequent breaking of these seals would be required. The Host Team Leader agreed with this change of procedure. Composition first Team (pick up 10.10 h.): inspector 1. A. Axelsson, inspector 2. I. Akiyama, inspector 3. H. Park.
Tasks: seal verification in utility room, retrieval of CCTV, CCTV commissioning (camera mounting, initialization of terminals, positioning & adjustment, sealing of camera mounts & positioning screws).

During seal verification, some of the photos of the seals were out of focus. Although the printed photos already had been compared with the actual seals in situ, for completion of this task as per the NuDiVe Dismantlement Steps and Procedures (2019) it was deemed necessary to take new photos of several seals on boxes that had not been opened already. Via the Host Team Leader, telephone contact with inspector 1 was established at 12.15 h. The seal numbers of the already opened boxes were communicated (0055221 and 0055222 on the General items box, and 005523 and 0055224 on the CCTV box). Out of focus photos of other seals (0055233, 0055235 and 0055236) were taken by the next team. Inspector 1 reported that the team was doing well and that it expected to finish the task around 13.00 h.

Via the MOT Procedure, the memory card was transferred to the Inspectors meeting room. Procedure MOT-2 requires the host to wear transparent gloves; they had none available. Host 2 also touched the memory card twice with his hand (procedure 5, steps 2 and 5). An inconsistency in step 9 was noted: it reads inspector 2 instead of inspector 3 (**Procedure**).

With regards to the seal application, the inspectors in the Inspector meeting room noted that the reflection caused by the reflective particle matrix in practice strongly depends on lighting conditions and camera angle. This leads to difficulties when comparing photos. The matrix itself, however, gives sharp lines in the photos. HQ to consider alternative matrixes (**Decision HQ**).

Two seals showed signs of slight lifting of the seals, potentially because of improper positioning or because of improper handling of the inspection material boxes. Also the observation was made that the seals seem not adequate for long term service.

At 12.30 h. host 1 phoned with the Inspection Team Leader to communicate that a shift change was immanent. This was verified with inspector 2, who confirmed the shift change. The Team had completed the task of mounting the CCTV cameras, and the sealing was performed by the next team. This was considered a more practical arrangement, than following the Procedures that describe installing one camera after the other. A hand-over between the Teams took place in the Confined Area, with surveillance of the mounted cameras.

The returned Team (13.15 h.) reported that after the inspection, the safety briefing – given by the Host Team in the morning – was not followed with regard to hand washing after the inspection. The Inspection Team Leader expressed his concerns to the Host Team Leader. He from his side expressed his regrets and promised to instruct his team.

The cooperation of the Host Team was excellent. They were open to suggestions for practical issues. The step by step approach in the NuDiVe Procedures was helpful to both Teams. It was noted that the Host Team did not wear the same protective clothing as was required from the Inspectors Team.
Composition of the second Team (pick up 13.00 h.): inspector 1. I. Almasi, inspector 2. M. Yu, inspector 3 A. Cholerzynski.

Team 2 first executed the sealing of the CCTV cameras. Each camera was sealed with two seals to the wall, and with on seal covering the angle adjustment screw; photos were taken. They also took photos of three seals on the equipment boxes to replace the earlier photos. The memory card was brought out of the Confined Area as before. The Team started the installation of the portal monitors, as per Procedure 6. The Team considered the cooperation with the Host Team good.

Procedure 6

Tasks: portal monitor commissioning (retrieval & seal check, placement & sealing, initialization & functionality test, sealing of portal monitor to floor, cable & laptop sealing).

Around 15.00 h. the second team was replaced by a third team. Composition of the third team (pick up 14.45 h.): inspector 1. A. Axelsson, inspector 2. H. Park, inspector 3. I. Akiyama.

Team 3 placed the seals on the portal monitors. The functional test for the portal monitors was performed. A start was made with procedure 4.

Procedure 4

Tasks: design verification (verification of structural design, objects present, diversion routes and application of seals).

Several potential diversion pathways were identified. Ventilation ducts were sealed. A discussion was started with the Host Team on finding a solution to securing pipes that would require a vast amount of seals. During the concluding meeting it was agreed that the Host Team will provide a plastic bag that can cover the pipes; this bag will then be sealed with a limited number of seals.

Tomorrow sweeping of the Dismantlement Room will take place. Arrangements have been agreed for sweeping the walls behind the furniture present. Drawers and doors of furniture were opened; nothing was in the furniture. This will be checked again tomorrow, when the design verification will be completed.

From one of the cameras the authentication seal (camera 2, number 003542) was inadvertently removed. This has to be corrected. For the current NuDiVe inspection, the camera will be under Chain of Custody; for a future inspection, this issue will have to be resolved (**for attention of Inspectorate HQ**).

The number of not-used memory cards is limited. Currently, only one card is available for use (it is in a camera). When asked if the number of memory cards is sufficient, the Host Team Leader answered that there are enough. In the concluding meeting, it was agreed that new memory cards would be supplied.

Procedure 4, General Documentation Task step 1 could not be completed because of refusal of by the Host Team to take photos of potential diversion pathways. This was addressed in the concluding meeting. The Inspection Team Leader asked the Host Team to consult the Procedure 4, and announced that tomorrow photos will be taken of potential diversion pathways.

Report to Inspectorate HQ by Inspection Team Urania
2019.09.26

The second starting meeting between the Team Leaders of both the Host and the Inspection Team, each accompanied by their Designate, took place at 09.00 h. The Host said that the event logfiles of the portal monitors were being prepared and would be given later this day. The Inspection Team Leader suggested that – as an exercise for the Inspection Team – the event log would be used to watch the CCTV footage. This was OK with the Host. The Host Team Leader asked what size of bag would be preferred to cover the piping in the Dismantlement Room: a big one or several smaller ones; a big one was preferred by the Inspection Team. The Host reported that one of the CCTV cameras (camera 1 above the entrance) was detached, and that the camera now was pointing to the ground. The Inspection Team Leader asked for remounting and for measures to prevent camera detachment in the future. This was agreed by the Host. He would also provide a detailed event report.

After this morning meeting, the Team continued the work.

The Host Team Leader requested somewhat later by telephone if it would be possible to simultaneously continue the design information verification (Procedure 4), and perform the CCTV data recovery task (Procedure 7, page 5 and 6). This was agreed. Later the Host Team Leader (alone) met just outside of the Inspectors meeting room with the Inspection Team Leader and his Designate. After some discussion on the number of inspectors in the team (Team 5) that was to perform the CCTV data recovery task, it was agreed to send three inspectors. This team would also perform the task of remounting the detached CCTV camera.

Procedure 4

Tasks: design verification (verification of structural design, objects present, diversion routes and application of seals).

Composition of the forth team (pick up 09.40 h.): inspector 1. A. Axelsson, inspector 2. H. Park, inspector 3. I. Akiyama.

Shortly after arrival in the Controlled Area, inspector 1 phoned the Inspectors meeting room. The Designate Inspection Team Leader answered the phone (Team Leader was absent). The Host Team had expressed it could not host more than two inspectors in Team 5. When the Inspection Team Leader returned, he called the Host Team Leader. He was not present, and his Designate answered the phone. He explained why the Host Team wished no more than two inspectors (other activities, follow Procedures). The Inspection Team Leader did not agree, and asked for the Host Team Leader to call back. The Designate Host Team Leader called again, and stated that the Host Team Leader was consulted, and that he agreed with the earlier message to have only two inspectors in Team 5. The Inspection Team Leader accepted the proposal – although it was not ideal – in order to continue the inspection. At 10.45 h. the Host Team Leader called because he had understood that there was a problem with the CCTV data recovery. The Inspection Team Leader stated not to be aware of such issue, and reiterated the discussion on the number of inspectors in Team 5. The Host Team Leader apologized for not personally conveying his change of opinion. Later that morning (11.05 h.), the Host Team Leader came and explained that he would go to the Controlled Area, and that for future communication a walky-talky would be available with one of the Host Team members. He also announced a shift change in his Host Team, and asked when the Inspectors Team 4 would have a shift change. This was not foreseen over the next hour, and hopefully they could finish their design verification task. The Inspection Team Leader telephoned with Inspector 1 of Team 4 at 11.10 h. to verify that the Host shift change had been announced to the Team. This was the case. Inspector 1 said to expect to finish in about an hour the design verification; the Team had already taken photos of potential diversion pathways, and was now in the process of sealing and taking photos of the seals. Inspector 1 would call around 12.00 h. to report on the progress.

Composition of Team 5 (pick up 09.50 h.): inspector 1. I. Almasi, inspector 2. M. Yu.

Procedure 7, pages 5 and 6

CCTV data recovery task

The data recovery procedure was executed with the help of the Host Team. The data were transferred to the Inspectors meeting room. At the exit of the Controlled Area, an inspector should have handed over the vial with the memory card, but instead a Host Team member held the vial. This observation is not considered a significant deviation from Procedures. Another observation is that the handling of the vial by inspectors in itself is not consistent with the requirement by the Host that inspectors should not touch anything within the Controlled Area.

In the Inspectors meeting room the CCTV footage was studied. From this, it became clear that camera 1 started to move downward around 18.10 h., and that around 20.38 h. the camera was swinging freely, just with its power cable attached. The Inspection Team concludes that no human interference took place. This was conveyed to the Host Team Leader. He was happy to hear that we came to this conclusion.

At 08.27 h. the Technical Team of the Host entered the Controlled Area, and observed every camera, apparently to check their positions. At 10.19 h. the camera was mounted again. The Inspection Team concludes that when it was not present itself, the CCTV footage gives no indication that the Host entered on other moments.

Continuation of design verification

Team 4 returned from the design verification (13.25 u.). They had completed the potential diversion pathways task, including photographing these. The photos were transferred to the Inspectors meeting room. The data transfer procedure was followed as in the Procedures. Team 4 is of the opinion that the Dismantlement Room is difficult to secure against diversion of small objects. The Inspection Team considers there is a need for more optimal containment solutions, e.g. for pipework, switch panels, et cetera.

Composition of Team 6 (pick up 13.55 h.): inspector 1. I. Almasi, inspector 2. M. Yu, inspector 3. A. Cholerzynski.

Team 6 was briefed by Team 5. Team 6 performed the verification of dimensions and the sweeping. The sweeping took about two times half an hour (both for gamma and neutron). When performing the gamma measurements, a spot with 0.05 microSv was found on a table in the right hand corner in the Dismantlement Room; elsewhere the radiation was around 0.01-0.03 microSv. During the design verification, consideration was given to the thickness of the wall between the Dismantlement Room and the Utility Room. No deviations from the declared dimensions were found.

Procedure 8

Tasks: absence measurements (radiation sweeping (gamma & neutrons)).

Team 6 performed the absence measurements.

The Host Team Leader and the Inspection Team Leader agreed to be present in the Controlled Area when the Treaty Accountable Item arrives and is brought to the Dismantlement Room.

Composition of Team 7 (pick up 15.20 h.): inspector 1. A. Axelsson, inspector 2. H. Park, inspector 3. O. Elahi.

Procedure 6

Task: portal monitor functionality test

The Host Team Leader denied the functionality test because of time constraints. The Inspection Team Leader proposed that the functionality test would be performed after the transfer of the Treaty Accountable Item, in order to gain some time. This was OK. The transfer of the Item took place without problems. The container of the Treaty Accountable Item had no identification tag, other than the seals that were applied by the previous Inspection Team (Team B). Then, the Host Team Leader presented the information that for security reasons, the portal monitor functionality task could not be performed. This meant in the Inspectors view that a second type of equipment was not 100% reliable in functioning as agreed under the Treaty (the first being the CCTV cameras, that already had proved unstable). The Host Team Leader suggested that the Treaty Accountable Item could be used to fulfill the test criteria for the portal monitor functionality test. As this is not per the Procedures, the Inspection Team could not accept this.

The Inspection Team requested that seals be placed on the Dismantlement Room door. This was acceptable for the Host Team Leader, under the condition that the reflective particle matrix would not be applied, and that no photographs were taken. The reason was provided that it would compromise the security of the most sensitive room in the facility. The counterproposal to take a picture of only part of the seal was also denied on similar grounds. The Inspection Team made other counter proposals, within the Procedures. The proposals of the Host Team Leader would not have allowed the Inspection Team to fulfill its obligations under the Treaty. It was concluded that the Treaty Accountable Item would be returned to the storage facility overnight, and that the next morning the Dismantlement Room would be checked again for gamma and neutron radiation.

Report to Inspectorate HQ by Inspection Team Urania
2019.09.27

The fifth day at Jülich Forschungszentrum started with an – out of NuDiVe – announcement that the Dismantlement Room had already been checked for gamma and neutron radiation, and that the Treaty Accountable Item would be brought in again from the storage facility, as agreed yesterday.

Procedure 10

Task: monitoring/verification of transfer of TAI from Controlled Area entrance to Dismantlement Room, SNM container to Non Destructive Analysis Room, and OC container to Non Destructive Analysis Room

Composition of Team 8: inspector 1 A. Axelsson, inspector 2 I. Akiyama, 3. inspector I. Almasi.

The Treaty Accountable Item was presented to the Team in the corridor of the Controlled Area. The seals were intact, and the portal monitor alarmed both for gamma and for neutron. It was then brought into the Disarmament Room. The boxes for the Special Nuclear Material and for the Other Components were also presented to the Inspection Team in the Controlled Area. They did not cause an alarm on the portal monitor. The acceptance of the empty containers is not explicitly in the Procedures.

The CCTV footage has been checked in the Inspectors meeting room. The Inspection Team has no concerns. Three seals were compromised when camera 1 fell of its mount. All other seals were checked, and they were all intact. A list of seals is sent to HQ in a separate message.

Composition of Team 9: inspector 1 A. Axelsson, inspector 2 I. Akiyama, 3. inspector A. Cholezynski.

The dismantlement was performed. The Host personnel went in and out of the Dismantlement Room several times, according to procedures. The Inspection Team was then invited into the Dismantlement Room to apply seals on the three containers. After the sealing, the Inspection Team did no more check Host personnel. After return to the Inspectors meeting room, it was realized that Host personnel should have been checked until the Dismantlement Room was checked for gamma and neutron radiation. The portal monitors were still functional. It is advised that the Procedures indicate until what moment Host personnel should be checked.

Composition of Team 10: inspector 1 I. Akiyama, Inspector 2 H. Park, inspector 3. M. Yu.

All equipment was decommissioned, inventoried and sealed according to the sealing procedures.

Conclusion

The Inspection Team concludes that the Host has successfully dismantled the Treaty Accountable Item as per the Treaty Procedures.

I.2. Inspection log sheets

NuDiVe Inspection Log

Inspection Logsheet Nº:____

Procedure	Time	Notes	Inspector ID/name

Date:	Inspector ID:	Page:

NuDiVe Inspection Log

Identification Number Protocol Nº:____

Identification number	Object	Location	Notes	Verification (note if replaced)

Date: Inspector ID: Page:

NuDiVe Inspection Log

Seal Application Protocol Nº:____

Seal Number	Object/Location	Application (time)	Verification (time)	Notes

Date:	Inspector ID:	Page:

I.3. Portal monitor event log

NuDiVe sensitive
Jülich Type-C inspection 23-27/09/2019

NuDiVe
Nuclear Disarmament Verification

Doc. No. SD002367826092019

Portal monitor alarm logsheet - 26092019

Portal Monitor n°1		**Portal monitor n°2**	
Gamma alarm	Neutron alarm	Gamma alarm	Neutron alarm
--------------------------Start of alarm recording : 16.30, 25/09/2019------------------------ Closure of the controlled area			
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--------------------------End of alarm recording : 09.00, 26/09/2019------------------------			

NuDiVe
Nuclear Disarmament Verification

I.4. Seal list

Seal Number	Object	Location	Application Date	Application Time	Application Inspector	Application Notes	Application Picture File Name (if different than seal number)	Verification Picture File Name (if different than seal number)	Seal Integrity verification (Ok/Compromised)	Removal Date	Removal Time	Location (if different)	Removal Inspector	Removal Notes
0055221	General Equipment box	Utility Room	08/30/19	15:50	RK				OK	09/25/19	10:33		AA, HP, IA	
0055222	General Equipment box	Utility Room	08/30/19	15:50	RK				OK	09/25/19	10:33		AA, HP, IA	
0055223	CCTV	Utility Room	08/30/19	14:58	RK				OK	09/25/19	11:50		AA, HP, IA	
0055224	CCTV	Utility Room	08/30/19	14:59	RK				OK	09/25/19	11:50		AA, HP, IA	
0055227	Gamma Monitor #1	Utility Room	08/30/19	15:39	RK				OK	09/25/19	10:59		AA, HP, IA	
0055228	Gamma Monitor #1	Utility Room	08/30/19	15:38	RK				OK	09/25/19	11:00		AA, HP, IA	
0055229	Gamma Monitor #2	Utility Room	08/30/19	15:41	RK				OK	09/25/19	11:01		AA, HP, IA	
0055230	Gamma Monitor #2	Utility Room	08/30/19	15:40	RK				OK	09/25/19	11:01		AA, HP, IA	
0055233	Neutron Monitor # 2	Utility Room	08/30/19	15:37	RK				OK	09/25/19	10:58		AA, HP, IA	
0055234	Neutron Monitor # 2	Utility Room	08/30/19	15:36	RK				OK	09/25/19	10:57		AA, HP, IA	
0055235	Neutron Monitor # 1	Utility Room	08/30/19	15:34	RK				OK	09/25/19	10:55		AA, HP, IA	
0055236	Neutron Monitor # 1	Utility Room	08/30/19	15:33	RK				OK	09/25/19	10:54		AA, HP, IA	
0055269	Portal Monitor equipment	Utility Room	08/30/19	15:31	RK				OK	09/25/19	N/A		AA, HP, IA	Inspectors did not record time of removal
0055270	Portal Monitor equipment	Utility Room	08/30/19	15:30	RK				OK	09/25/19	N/A		AA, HP, IA	Inspectors did not record time of removal
0055271	Portal Monitor batteries	Utility Room	08/30/19	15:26	RK				OK	09/25/19	N/A		AA, HP, IA	Inspectors did not record time of removal
0055272	Portal Monitor batteries	Utility Room	08/30/19	15:25	RK				OK	09/25/19	N/A		AA, HP, IA	Inspectors did not record time of removal
0055273	Portal Monitors	Utility Room	08/30/19	15:16	RK				OK	09/25/19	N/A		AA, HP, IA	Inspectors did not record time of removal
0055274	Portal Monitors	Utility Room	08/30/19	15:15	RK				OK	09/25/19	N/A		AA, HP, IA	Inspectors did not record time of removal
0055277	Right	Hallway	09/25/19	13:35					Compromised	N/A	N/A	N/A		adhesive failed. Seal
0055278	CCTV Camera 1 mount- Left	Hallway	09/25/19	13:35					Compromised	N/A	N/A	N/A		Camera mounting adhesive failed. Seal compromised
0055279	CCTV Camera 1 - screw	Hallway	09/25/19	13:35		Seal damaged during application. Changed to 0055280		N/A	Compromised	N/A	N/A	N/A		N/A

Seal Number	Object	Location	Application Date	Application Time	Application Inspector	Application Notes	Application Picture File Name (if different than seal number)	Verification Picture File Name (if different than seal number)	Seal Integrity verification (Ok/Compromised)	Removal Date	Removal Time	Location (if different)	Removal Inspector	Removal Notes
0055280	CCTV Camera 1 - screw	Hallway	09/25/19	13:38					OK	N/A	N/A	N/A		Camera mounting adhesive failed. Seal compromised
0055281	CCTV Camera 2 mount - Right	Hallway	09/25/19	13:45					OK	09/27/19	12:00		AA, HP, IA	
0055282	CCTV Camera 2 mount- Left	Hallway	09/25/19	13:45					OK	09/27/19	12:00		AA, HP, IA	
0055283	CCTV Camera 2 - screw	Hallway	09/25/19	13:45					OK	09/27/19	12:01		AA, HP, IA	
0055284	CCTV Camera 3 mount - Right	Hallway	09/25/19	13:49					OK	09/27/19	12:05		AA, HP, IA	
0055285	CCTV Camera 3 mount- Left	Hallway	09/25/19	13:49					OK	09/27/19	12:06		AA, HP, IA	
0055286	CCTV Camera 3 - screw	Hallway	09/25/19	13:49					OK	09/27/19	12:06		AA, HP, IA	
0055287	CCTV Camera 4 mount- Left	Utility Room	09/25/19	13:50					OK	09/27/19	12:10		AA, HP, IA	
0055288	CCTV Camera 4 mount - Right	Utility Room	09/25/19	13:51		Seal damaged during application. Changed to 0055289	N/A	N/A	N/A	N/A	N/A	N/A	AA, HP, IA	N/A
0055289	CCTV Camera 4 mount - Right	Utility Room	09/25/19	13:52					OK	09/27/19	12:10		AA, HP, IA	
0055290	CCTV Camera 4 - screw	Utility Room	09/25/19	13:59					OK	09/27/19	12:11		AA, HP, IA	
0055291	CCTV Camera 5 mount- Left	Utility Room	09/25/19	14:02					OK	09/27/19	12:15		AA, HP, IA	
0055292	CCTV Camera 5 mount - Right	Utility Room	09/25/19	14:04					OK	09/27/19	12:15		AA, HP, IA	
0055293	CCTV Camera 5 - screw	Utility Room	09/25/19	14:05					OK	09/27/19	12:16		AA, HP, IA	
0055308	HVAC vent	Dismantlement Room	09/25/19	16:00	AA, HP, IA				OK	09/27/19	12:20		AA, HP, IA	
0055309	HVAC vent	Dismantlement Room	09/25/19	16:00	AA, HP, IA				OK	09/27/19	12:20		AA, HP, IA	
0055325	Panel	Dismantlement Room	09/26/19	10:55	AA, HP, IA				OK	09/27/19	12:21		AA, HP, IA	

Seal Number	Object	Location	Application Date	Application Time	Application Inspector	Application Notes	Application Picture File Name (if different than seal number)	Verification Picture File Name (if different than seal number)	Seal Integrity verification (Ok/Compromised)	Removal Date	Removal Time	Location (if different)	Removal Inspector	Removal Notes
0055326	Panel	Dismantlement Room	09/26/19	10:59	AA, HP, IA				OK	09/27/19	12:21		AA, HP, IA	
0055327	Panel	Dismantlement Room	09/26/19	10:58	AA, HP, IA				OK	09/27/19	12:23		AA, HP, IA	
0055328	Panel	Dismantlement Room	09/26/19	11:00	AA, HP, IA				OK	09/27/19	12:24		AA, HP, IA	
0055329	Panel	Dismantlement Room	09/26/19	11:01	AA, HP, IA				OK	09/27/19	12:25		AA, HP, IA	
0055330	Panel	Dismantlement Room	09/26/19	11:03	AA, HP, IA				OK	09/27/19	12:25		AA, HP, IA	
0055332	Panel	Dismantlement Room	09/26/19	11:05	AA, HP, IA				OK	09/27/19	12:26		AA, HP, IA	
0055333	Panel	Dismantlement Room	09/26/19	11:07	AA, HP, IA				OK	09/27/19	12:26		AA, HP, IA	
0055334	Panel	Dismantlement Room	09/26/19	11:08	AA, HP, IA				OK	09/27/19	12:27		AA, HP, IA	
0055335	Panel	Dismantlement Room	09/26/19	11:11	AA, HP, IA				OK	09/27/19	12:27		AA, HP, IA	
0055336	Panel	Dismantlement Room	09/26/19	11:13	AA, HP, IA				OK	09/27/19	12:28		AA, HP, IA	
0055337	Panel	Dismantlement Room	09/26/19	11:14	AA, HP, IA				OK	09/27/19	12:29		AA, HP, IA	
0055338	Panel	Dismantlement Room	09/26/19	11:15	AA, HP, IA				OK	09/27/19	12:29		AA, HP, IA	
0055339	Wall	Dismantlement Room	09/26/19	11:17	AA, HP, IA				OK	09/27/19	12:30		AA, HP, IA	
0055340	Wall	Dismantlement Room	09/26/19	11:18	AA, HP, IA				OK	09/27/19	12:31		AA, HP, IA	
0055341	Wall	Dismantlement Room	09/26/19	11:20	AA, HP, IA				OK	09/27/19	12:33		AA, HP, IA	
0055342	Wall	Dismantlement Room	09/26/19	11:21	AA, HP, IA				OK	09/27/19	12:33		AA, HP, IA	
0055343	Panel	Dismantlement Room	09/26/19	11:23	AA, HP, IA				OK	09/27/19	12:34		AA, HP, IA	
0055344	Panel	Dismantlement Room	09/26/19	11:24	AA, HP, IA				OK	09/27/19	12:34		AA, HP, IA	
0055345	Panel	Dismantlement Room	09/26/19	11:25	AA, HP, IA				OK	09/27/19	12:34		AA, HP, IA	
0055346	Wall	Dismantlement Room	09/26/19	11:27	AA, HP, IA				OK	09/27/19	12:35		AA, HP, IA	
0055347	Wall	Dismantlement Room	09/26/19	11:28	AA, HP, IA				OK	09/27/19	12:36		AA, HP, IA	
0055348	Wall	Dismantlement Room	09/26/19	11:30	AA, HP, IA				OK	09/27/19	12:37		AA, HP, IA	
0055349	Wall	Dismantlement Room	09/26/19	11:32	AA, HP, IA				OK	09/27/19	12:38		AA, HP, IA	
0055350	Wall	Dismantlement Room	09/26/19	11:33	AA, HP, IA				OK	09/27/19	12:38		AA, HP, IA	
0055351	Wall	Dismantlement Room	09/26/19	11:34	AA, HP, IA				OK	09/27/19	12:40		AA, HP, IA	
0055352	Wall	Dismantlement Room	09/26/19	11:37	AA, HP, IA				OK	09/27/19	12:40		AA, HP, IA	
0055353	Wall	Dismantlement Room	09/26/19	11:38	AA, HP, IA				OK	09/27/19	12:41		AA, HP, IA	
0055354	General Equipment box	Utility Room	09/26/19	11:47	AA, HP, IA				OK	09/27/19	12:42		AA, HP, IA	

Seal Number	Object	Location	Application Date	Application Time	Application Inspector	Application Notes	Application Picture File Name (if different than seal number)	Verification Picture File Name (if different than seal number)	Seal Integrity verification (Ok/Compromised)	Removal Date	Removal Time	Location (if different)	Removal Inspector	Removal Notes
0055355	General Equipment box	Utility Room	09/26/19	11:48	AA, HP, IA				OK	09/27/19	12:44		AA, HP, IA	
0055356	Wall	Dismantlement Room	09/26/19	11:49	AA, HP, IA				OK	09/27/19	12:45		AA, HP, IA	
0055357	Wall	Dismantlement Room	09/26/19	11:51	AA, HP, IA				OK	09/27/19	12:46		AA, HP, IA	
0055358	Wall	Dismantlement Room	09/26/19	11:52	AA, HP, IA				OK	09/27/19	12:47		AA, HP, IA	
0055359	Wall	Dismantlement Room	09/26/19	11:53	AA, HP, IA				OK	09/27/19	12:48		AA, HP, IA	
0055360	Wall	Dismantlement Room	09/26/19	11:53	AA, HP, IA				OK	09/27/19	12:48		AA, HP, IA	
0055361	Wall	Dismantlement Room	09/26/19	11:54	AA, HP, IA				OK	09/27/19	12:48		AA, HP, IA	
0055362	Wall	Dismantlement Room	09/26/19	11:56	AA, HP, IA				OK	09/27/19	12:49		AA, HP, IA	
0055363	Drain	Dismantlement Room	09/26/19	11:58	AA, HP, IA				OK	09/27/19	12:50		AA, HP, IA	
0055364	Drain	Dismantlement Room	09/26/19	11:59	AA, HP, IA				OK	09/27/19	12:51		AA, HP, IA	
0055365	Drain	Dismantlement Room	09/26/19	11:59	AA, HP, IA				OK	09/27/19	12:51		AA, HP, IA	
0055366	Drain	Dismantlement Room	09/26/19	12:00	AA, HP, IA				OK	09/27/19	12:52		AA, HP, IA	
0055367	Drain	Dismantlement Room	09/26/19	12:01	AA, HP, IA				OK	09/27/19	12:52		AA, HP, IA	
0055368	Drain	Dismantlement Room	09/26/19	12:01	AA, HP, IA				OK	09/27/19	12:53		AA, HP, IA	
0055369	Drain	Dismantlement Room	09/26/19	12:03	AA, HP, IA				OK	09/27/19	12:53		AA, HP, IA	
0055370	Drain	Dismantlement Room	09/26/19	12:03	AA, HP, IA				OK	09/27/19	12:53		AA, HP, IA	
0055277	CCTV Camera 1 mount - Right	Hallway	09/27/19	10:10	IAL, AC, MY				OK	09/27/19	12:55		AA, HP, IA	
0055278	CCTV Camera 1 mount- Left	Hallway	09/28/19	10:10	IAL, AC, MY				OK	09/27/19	12:55		AA, HP, IA	
0055280	CCTV Camera 1 - screw	Hallway	09/29/19	10:10	IAL, AC, MY				OK	09/27/19	12:56		AA, HP, IA	

J. Evaluation

J.1. Questions for the Evaluation Team

NuDiVe
Nuclear Disarmament Verification

The NuDiVe Exercise

The German-French Exercise for the International Partnership for Nuclear Disarmament Verification's Phase II

Questions for Evaluation of the NuDiVe Exercise

1

Goal

NuDiVe focuses on the technologies and procedures providing sufficient confidence about the absence of diversion of nuclear materials during the dismantlement operation of a nuclear warhead within a treaty-related disarmament regime. When preparing the exercise, the French and German organizers noted various aspects for the evaluation they are interested in. These are compiled in this document.

Question 1

The overarching goal of NuDiVe is to verify that the concept developed by IPNDV for verification of the dismantlement of a NED is both efficient and creates confidence that the dismantlement has been performed as declared. A first evaluation dimension would therefore be on the exercise design and if it was well suited for the procedures that are implemented.

a) Does the NUDiVe design allow to contribute to this goal?

b) Does NuDiVe reveal major conceptual difficulties with IPNDV's approach?
If yes, please specify.

Question 2

Did you note potential proliferation risks, or release of any sensible information, which require further consideration? Were the procedures appropriately designed to respond to these risks?

Question 3

If NuDiVe will be repeated, do you propose additions or modifications for further increasing its realism?

Question 4

Are the procedures, which are exercised in NuDiVe, (a) adequate[1], (b) robust[2], and (c) efficient[3]?

Question 5

Are the CoC technologies used in NuDiVe (a) adequate[1], (b) robust[2], and (c) efficient[3]?

Question 6

Are the technologies, which are applied in NuDiVe for verifying the presence or absence of SNM, (a) adequate[1], (b) robust[2], and (c) efficient[3]?

[1] "Adequate" meaning that the procedures get the task done.
[2] "Robust" meaning the procedures are unlikely to fail in case of varying incidents or circumstances.
[3] "Efficient" meaning the procedures require the minimum amount of effort to get the task done.

2

J.2. Report by the Evaluation Team

NuDiVe Exercise

Forschungszentrum Jülich, 23-27 September 2019

Report by the Evaluation Team

Contents

Summary of observations

1. The Nuclear Disarmament Verification (NuDiVe) exercise organised by Germany and France successfully tested, under many realistic conditions, a key step in an inspection process for multilateral verification of the dismantlement of a Nuclear Explosive Device (NED). An "inspection team" of experts from seven countries applied verification measures immediately prior to and following a notional dismantlement[1] of a NED to gain assurance of the non-diversion of fissile material. A "host team", representing the fictional inspected state of "Urania," used managed access arrangements designed to prevent any disclosure of information that could pose a risk for proliferation of nuclear weapons or other sensitive information. Procedures followed in the exercise were prepared by the exercise organisers, building on inspection concepts and approaches developed by the International Partnership for Nuclear Disarmament Verification (IPNDV). An independent evaluation team observed the exercise. Preliminary observations from the exercise included:

a) The inspection team was generally satisfied that it had successfully applied the procedures to establish containment and surveillance measures to detect any diversion of fissile material or weapons components from the area where the notional dismantlement took place.

1 Dismantlement refers to the physical process of separating special nuclear material from high explosives and other components.

b) Evaluators and exercise participants consider that the exercise demonstrated that the IPNDV-developed inspection concepts and approaches on which the exercise was based are sound. More work is needed to improve efficiency and effectiveness of the inspection process, including steps to ensure that strategic inspection objectives are not lost when implementing the detail of an inspection.
c) Evaluators and exercise participants identified ways in which detailed inspection procedures used in the exercise should be refined and augmented, for example, redesigning some procedural steps so that inspection effort and resources can be more clearly focused on critical inspection objectives.
d) Inspection equipment employed in the exercise demonstrated value, with knowledge gained by this deployment of technical tools providing ideas for future development. Evaluators and exercise participants identified areas for further work.
e) The inspection scenario developed by the exercise organisers, and the facilities offered by the Jülich Research Centre, added realism to the exercise. Useful lessons were learned on how to enhance the value of gameplay in future exercises, including to ensure activities are best aligned with the strategic objectives of an inspection.
f) Participants highlighted the value of practical exercises in future work on nuclear disarmament verification, particularly for developing, testing, and refining IPNDV concepts and approaches, and in building and maintaining the expert capacity needed to advance this work.

Recommendations to IPNDV partners

2. Future work by IPNDV and its partners can benefit from many of the lessons identified through the NuDiVe exercise. The evaluation team highlights the following points raised in this report:

Equipment and technology

i. Significant work needs to be done not just to develop useful technologies, but also to produce systems that are functional and reliable in the context of an inspection (paragraph 45), including a CCTV system (paragraph 11) and portal monitor (paragraph 14).
ii. Evaluators and exercise participants offered suggestions for improving the design of handheld detectors that may be used in inspections (paragraph 15).
iii. The sealing kit could be improved (paragraph 16).
iv. Tools to facilitate communication between and within teams could be further developed (paragraph 17).
v. Discussion is needed on ways to mitigate impacts to inspection effectiveness and inspector wellbeing that may result from the use of Tyvek inspection suits (paragraph 18).
vi. Some lessons on facility design were identified (paragraph 19).
vii. Information barrier techniques may be needed for the radiation detection technologies used in facility design checks to prevent disclosure of background count rates (paragraph 20).
viii. Work is required on approaches to confirm that an item is non-nuclear without divulging sensitive information (paragraph 22).

Inspection procedures

ix. Evaluators formed a view that reliance on following detailed procedures came at a cost to independent and strategic thinking for both inspection and host team members (paragraph 26).

x. Better prioritisation of inspections tasks may have enabled adequate assurance, but with less effort, if a holistic approach to risk could be taken. IPNDV should discusses how a systems approach could be applied to the design of containment and surveillance (C&S) systems (paragraph 28).

xi. IPNDV should discuss the kinds of information that should be available to inspectors for their planning, including planning that may be conducted prior to the arrival on-site of an inspection team (paragraph 29).

xii. To facilitate a shift from the very conceptual work of IPNDV to the very practical requirements of an inspection or exercise, IPNDV should consider the nature and structure of guidance that would be needed to support a multilateral inspection and that facilitates a balancing of the interests of participants (paragraphs 32, 33).

Interaction between the inspection and host teams

xiii. A perception of power imbalance may be inevitable for inspections at high security sites, but could colour the judgements that inspectors make. IPNDV could consider ways in which this problem could be managed (paragraph 37).

xiv. Early and regular discussions between teams (both formal and informal) about their respective objectives in an inspection should promote a cooperative culture (paragraph 40).

xv. A future exercise (or pair of exercises) might alternate host and inspector roles in order to promote non-adversarial outcomes (paragraph 40).

Lessons for future exercises

xvi. Playing teams should be more fully trained ahead of an exercise. IPNDV should consider how it may establish a cadre of experts with training in techniques and methodologies relevant to nuclear disarmament verification. An early step in this direction could be for IPNDV to prepare a list of relevant competencies for which a training program could be developed for a future exercise (paragraph 53).

xvii. An active and independent control team is useful for managing the flow of an exercise and to help to put things back on track if necessary (paragraph 56).

xviii. Future exercise organisers should consider additional guidance for playing teams so that each can work to a coherent strategy (paragraph 58).

Overview of the NuDiVe Exercise

3. The overarching goal of NuDiVe was to verify that the concepts developed by IPNDV for verification of the dismantlement of a NED (as tested by the exercise) are effective, efficient and potentially usable. The exercise focused on the ability of the IPNDV-identified inspection approaches, procedures and technologies to provide assurance of the non-diversion of nuclear materials and other components during notional nuclear warhead dismantlement operations. In particular, the exercise focused on implementation of inspection approaches in steps 8.1, 8.3 and 8.4 of verification of NED dismantlement as developed by IPNDV within the 14 Step document developed during IPNDV's Phase II (see Box 1). Detailed inspection procedures were developed by the exercise organisers to implement the IPNDV-developed approaches.

Box 1. Key IPNDV-develop inspection approaches tested in NuDiVe

8.1) Confirm chain of custody for the item to be dismantled

- Prior to dismantlement, the inspection team checks tags, seals, and UIDs on each accountable item to be dismantled and if necessary reviews surveillance data for the item[2].

8.2) If needed to re-confirm consistency with declarations of each accountable item to be dismantled, an inspection team[3]:

- Observes and measure item attributes (mainly radiation measurements) to confirm consistency with declared verifiable characteristics; and/or
- checks against an applicable template for the item.

8.3) Confirm that no SNM or HE[4] is present in the dedicated dismantlement area prior to or following dismantlement

- The inspection team "sweeps" the area under managed access, using hand-held monitoring equipment to detect any SNM or HE.

8.4) Confirm that the only accountable items to enter or leave it are those which have been declared and that no SNM is diverted during the course of the dismantlement operations

- An inspection team:
  - Makes visual observations and/or applies portal monitoring and other applicable C&S measures to ensure that the declared NED and empty component containers are the only accountable items to enter or be removed from the dedicated dismantlement area.
  - Applies seals in the dismantlement area at potential diversion pathways
  - Checks host staff entering and leaving the dismantlement area by radiation monitors.

4. The scenario for the exercise focused on inspection activities at a notional multi-purpose facility, that is: a facility where various nuclear weapon-related activities take place, but where a designated location within a "controlled area" is used for verified dismantlement. All inspection activities, aside from planning and data analysis, were conducted in the controlled area, which consisted of three rooms and an adjacent corridor.

2 There was no check of a UID or of prior surveillance data.
3 Step 8.2 was not exercised in NuDiVe
4 SNM: special nuclear material, HE: high explosive

5. NuDiVe was conducted as a gameplay exercise, with participants assigned roles in the following groups:

- host technical personnel, including Jülich staff supporting the exercise (blue shirt);
- host team, representing "Urania" (red shirt)
- inspection team, from a notional multilateral verification entity (black shirt)
- evaluation team (green shirt)

6. The NuDiVe exercise took place over five days. The first day and a half was for training of external participants in behavioural rules for, and technologies used during, the exercise; the final half-day was used for a post-exercise "hot-wash" discussion. For the remainder of the week, the host and inspection teams planned, discussed and conducted inspection activities independently, then jointly to reach agreement on daily activities. The inspection team prepared daily reports (to a notional inspectorate headquarters) describing its activities.

Evaluation process and methodology

7. The five-person evaluation team[5] observed all inspector-host interactions and most internal team discussions. Evaluators formed views based on direct observation of exercise activities, including in-game comments by many of the exercise players. Outside of exercise play, interviews were conducted with exercise organisers and team leaders, and all players completed questionnaires at the beginning and end of the inspection phase of the exercise. Comments during the post-exercise hot-wash were also noted. Table 1 contains the list of key questions that were developed by the evaluation team ahead of the exercise to assist with the evaluation process. Some lessons outside this framework emerged also.

Table 2. Key questions for evaluators

Target	Key Questions
a) Use and performance of inspection technologies	What do the technologies do well? What do they not do well?
	What are the gaps in technical capability and design?
b) Value of inspection approaches and procedures	What do the inspection approaches and procedures do well / not so well?
	Were the procedures easy to use and understand?
	To what extent were inspection approaches and procedures effective in confirming the object of the inspection? To what extent were inspection approaches and procedures efficient in minimizing the time and effort needed to complete the inspection?
	If applicable, how well were discrepancies resolved?
c) Interaction between the inspection and host teams	How well did managed access measures related to proliferation risk and national security/safety work for the inspected state?
	To what degree did security / safety measures impact conduct of the inspection?
	What matters needed to be negotiated "on the ground" and were the

5 Malcolm Coxhead and Rob Floyd (Australia), Corey Hinderstein (NTI), Alicia Swift (USA), Ralf Straub (Switzerland)

	outcomes mutually satisfactory?
d) Overall assessment of inspection activities	To what degree did the inspection activities provide confidence that state declarations were accurate? Detract from confidence? How close are we to inspection approaches and technologies that are technically and practically sound?
e) Assessment of the exercise scenario design, venue and organisation for testing IPNDV and ideas	Was the exercise effective for testing IPNDV-developed verification concepts? What lessons are there for future exercises? Was the training on the procedures / technologies adequate to accomplish the exercise objectives? Was useful knowledge shared between the NNWS and NWS participants?

Evaluation results: Use and performance of inspection technologies

8. The following inspection-specific technologies and equipment were used during NuDiVe (along with various auxiliary items, e.g., for note-taking):

- sealing kit (transparent bag, handheld cameras, camera batteries and SD memory cards, adhesive seals, reflective particle matrix)
- portal monitor units and associated gamma and neutron test sources
- CCTV cameras
- computer terminals (laptops) for portal monitor and CCTV cameras
- neutron search detector
- handheld gamma detector
- handheld camera, camera batteries and SD memory cards
- SD flash memory for cameras and clear plastic vials for transfer from the controlled area
- tape measure and laser distance meter
- fixed-line telephone for communication between the controlled area and the inspection team's office
- high-density polyethylene (Tyvek) inspection suit, plus overshoes and latex gloves
- dosimeter and handheld contamination monitor (for health and safety purposes).

9. At the end of the exercise, the inspection team declared itself satisfied that it had been able to apply adequate C&S measures to detect any diversion of fissile material from the dismantlement area. In this respect, the technologies and equipment used in NuDiVe performed adequately. Although equipment systems such as the CCTV cameras and portal monitor systems are prototypes, and clear areas for improvement were identified, the value of such tools in an inspection was recognised by exercise players and evaluators. Inspectors used the sealing kit extensively and did not identify any failure of a seal that undermined their task.

CCTV

10. Exercise participants recognised the potential for CCTV monitoring as a useful element of a C&S system. That said, the inspectors considered it as a secondary layer in their C&S model. It was not practical for them to review all video to identify an event of concern, and access to video was requested only to investigate events observed in other ways. Confidence in CCTV during the exercise was undermined by the failure of a camera wall-mount and damage to the mounted camera when it fell.

11. For this exercise, four consumer-grade internet protocol video cameras were used and linked to a control terminal using WiFi. Although a practical choice for the exercise, evaluators (and organisers) noted that the use of WiFi, and some types of consumer-grade cameras, may not be desirable where data security and authenticity and system performance is critical. Evaluators and exercise players offered additional suggestions for development of an improved CCTV system:

- Additional CCTV cameras may be needed to maintain line of sight (there were blind spots in this exercise).
- Tools could be developed to make the review of video more efficient. These might be implemented using automated review software with image change detection.
- Synchronisation of CCTV clocks with those used with other equipment (e.g. portal monitors) may be needed.
- Evaluators observed that inspectors working in the controlled area sometimes struggled to monitor for any tampering with their unsealed equipment. If a CCTV viewer was available outside the controlled area, an additional inspector (under escort) could monitor that equipment, thus freeing inspectors working inside from an extra task. This could also simplify shift-change requirements.

Portal Monitor

12. Evaluators and exercise participants recognised that portal monitoring is a very useful technology for this type of inspection. An excellent portal monitor was available, but design refinements would be needed to make it fully suitable for use in a dismantlement inspection..

13. With respect to effectiveness of the system, some exercise participants did not feel that calibration tests were consistent with the operational environment in which they would be asked to perform during an inspection. Some noted that if the test sources for gamma and neutron detectors are stronger than the actual gamma or neutron emissions of a warhead, functionality testing will not be effective. There was also some concern about possible false alarms, possibly due to the detector sensitivity and large field of view, resulting in a negotiated change to procedures (moving the item container into the NDA room).

14. In terms of functionality, suggestions were made that the alert signal following a detection could be improved, for example, by adding an alert sound. Inspectors expressed a desire also to have open access to a log of timestamps for when alerts had been detected. A suggestion was made that portal monitor alerts should be logged in time in parallel with the CCTV system.

Handheld neutron and gamma detectors

15. Evaluators and exercise participants offered suggestions for improving the design of handheld detectors that may be used in inspections:

- As the detectors were heavy, and it was sometimes awkward to sweep along the vertical walls, particularly at the ceiling level which required taller host team members to carry out the activity. Perhaps detectors need to be placed on a rod to reach higher places, and their weight reduced, if feasible.
- The gamma detector crystal was small, which meant that sweeping the wall was slow.
- The gamma detector had an additional capability that allowed for identification of isotopics, which is a host information protection concern. In the exercise, it was handled with an administrative control (i.e., don't use that setting) and operated by host personnel, but engineering controls, or a design that excludes a sensitive capability, would be better.

Sealing

16. Inspectors applied a large number of seals during the exercise. Various suggestions were made for the available sealing kit to be improved:

- Consistency in the photographing of seals and their reflective particle matrix proved to be challenging, especially where seals were applied in locations where use of a camera was difficult. Even where camera access was not a problem, more could be done to ensure consistency with respect to the distance from which photos are taken and the angle at which they are taken. The use of a tripod, for example, could be helpful.
- Only one kind of seal (i.e., adhesive seal of one size) was available. Different seal types (e.g., loop seals, adhesive seals of various sizes) may be better suited to some situations. Some inspectors considered the use of paper/plastic seals to be too rudimentary.
- Evaluators considered that some seals applied during the exercise might have been compromised (in a minor way), either due a poor application or their use in a situation for which they are not well suited.

Local Communications

17. Exercise players commented that tools to facilitate communication between host and inspector teams, and also within teams, could be further developed. Such tools are important for communication with people working in a controlled area. Handheld radios were used by most NuDiVe teams, although inspectors were limited to use of a fixed-line telephone – held up to their ear by a host team member when working in the controlled area to prevent the inspector from touching the surface. An alternative could be to use CCTV as an intercom (cameras used in NuDiVe were not set up to record sound). This should not require inspectors to touch any communications device when working in a controlled area.

Inspector dress in controlled area

18. High-density polyethylene (Tyvek) inspection suits were used by inspectors in the controlled area to prevent swipe sampling. The impact of hot and uncomfortable suits on inspector performance and wellbeing was a subject of considerable discussion during the exercise. Various suggestions

were made, either to review the strictness of requirements for their use, and/or to develop suits with materials and design features better suited to use during inspections. Evaluators recognise that avoidance of swipe sampling will be an important requirement, especially in multi-purpose facilities. IPNDV should discuss ways to mitigate impacts on inspection effectiveness and inspector wellbeing that may result from the use of inspection suits of the kind used in NuDiVe.

Facility design

19. Although a facility where verification is conducted is not per se inspection equipment or technology, it is recognised that the facility design will be an important factor in verification. NuDiVe did not address the larger question of whether a purpose-built facility is needed, but did offer a few lessons on aspects of facility design:

- The size of the controlled area rooms may be a significant limiting factor for the pace of inspections. Requests by the inspection team to conduct some activities in parallel were not able to be accommodated.
- Entry and exit from the controlled area was also a limiting factor for the pace of inspection activities. The available facilities and space at the entry point slowed the dressing and undressing of inspectors.
- The presence of various ports in the dismantlement room (e.g., for power, water, air-conditioning) complicated sealing requirements. If a room design that minimises such ports is possible, it could aid inspection efficiency.
- The reluctance of the host team to share information with inspectors to enable them to plan their activities appeared to be a result of sensitivities about facility design. To overcome the kinds of delays experienced during NuDiVe, ways will need to be found to share enough information for effective inspection planning.

Additional suggestions

20. A number of participants identified a need for further work on measurement techniques and information barriers. For example, evaluators noted that there was a general assumption in the exercise that radiation count rates (background, warhead components) are minor and shareable. These may not be good assumptions in reality, and may lead to false positives. Information barrier techniques may be needed for the radiation detection technologies to prevent disclosure of background count rates.

21. Several participants highlighted the need for further work on authentication / certification procedures (these were not exercised).

22. Various ad hoc approaches needed to be explored by the host team for demonstrating that some items (e.g., shrouded removable tools) are non-nuclear. Further work is required on approaches to confirm that an item is non-nuclear without divulging sensitive information.

23. To attempt to detect a possible wall cavity adjacent to the dismantlement room, inspectors asked host team members to knock on walls to listen for changes in acoustics. This is a very rudimentary technique and work on additional approaches could be considered.

Evaluation results: Value of inspection approaches and exercise procedures

24. After working with the detailed inspection procedures prepared for NuDiVe, the inspection team judged that it had been able to apply adequate C&S measures to detect any diversion of fissile material from the dismantlement area. These procedures were based on the inspection approaches developed by IPNDV (see Box 1). This attests positively to the value of the IPNDV-developed concepts and of the organiser-developed NuDiVe procedures. It was evident, however, to evaluators and participants that much could be done to improve the efficiency of the procedures and how they were applied in NuDiVe. Improved efficiency should also enhance effectiveness and limit mistakes.

25. Many of the participants implementing the NuDiVe procedures said that the procedures were well written and praised their helpful detail and clarity. Suggestions were made that a flow-chart approach to their presentation could be useful also to assist with visualisation of inspection tasks.

26. The clarity of the procedures document was probably a significant factor aiding its use. Evaluators formed a view, however, that reliance on following the procedures came at a cost to independent and strategic thinking for both inspection and host team members. The evaluation team observed some in-play mistakes[6] that may have been due to a narrow focus on application of inspection procedures. Additional training in the application of exercise-specific procedures could help here (see *training*), however, the evaluators consider that this could only be one part of an answer.

27. NuDiVe inspectors planned their inspection activities on the basis of only limited information about the locations where they would conduct inspection activities. They also had little information about verification activities that had notionally taken place during earlier inspections. They worked from first principles to establish C&S in the controlled area, including by sealing off a wide range of possible diversion routes.

A systems approach

28. Evaluators felt that inspectors may be able to fulfil their task with less effort than was needed in NuDiVe if inspection tasks could be prioritised based on a holistic approach to risk. For example, the effort required for placement and checking of seals by inspectors could be reduced. IPNDV has begun a discussion on applying a "systems approach" to verification on the basis that not all verification measures would need to be applied at every step, and confidence in the overall effort is built through the combination of activities throughout an ongoing dismantlement process. In light of the NuDiVe experience, the evaluators recommend that IPNDV further discusses how a systems approach could be applied to the design of C&S systems. In this respect, the scenario and inspection activities in NuDiVe could provide the basis for a case study, with the aim of identifying efficiencies.

29. Adoption of a systems approach in inspections requires that inspectors are well briefed on the physical scenario they will face on the ground and on the history of (and future plans for) verification at the site. Such information was not available in NuDiVe before inspection activities began. While

6 For example, evaluators noted that focus on shift-change procedures sometimes distracted players from passing on necessary information to their replacements.

this offers a lesson for planning of future exercises, it also highlights the need for IPNDV to discuss the kinds of information that should be available to inspectors for their planning, including planning that may be conducted within a verification entity prior to the despatch of an inspection team, as well as the associated timeline for sharing information.

Inspection guidance documents

30. The primary written guidance for the conduct of inspection activities in NuDiVe was a set of procedures on the use of inspection equipment in the controlled area. There was also a document with “behavioural rules”. Some of the behavioural rules addressed gameplay, as well as real-world safety issues for the Jülich site. They also included guidance on inspector dress and behaviour, especially in the controlled area.

31. Some confusion arose on the in-game status of the inspection procedures document – in particular, whether the procedures were fixed (e.g. treaty level) and about what scope there was to add to them or adapt them. It became clear several times that additional activities may be needed to resolve disputes or to address unexpected events. In response, the organisers clarified that some latitude to add new procedures was possible. Evaluators observed discussion in the host team on how wide such latitude should be, with some players expressing a concern that flexibility should not be excessive. It is recommended for future exercises that such guidance be clear prior to the start of the exercise.

32. The evaluators observed several examples of issues that may need to be addressed in inspection guidance. Some of these go beyond the addition of new practical procedures and point to the need for IPNDV to consider a wider set of guidance that would be appropriate for a multilateral inspection regime and which facilitates a balancing of the interests of participants in an inspection:

- The procedures did not include a mechanism to protect inspectors’ working documents or tools (e.g. laptops) overnight within the inspection team’s planning room, outside of the controlled area. Aside from the need for specific sealing tools, this observation highlights a need to consider the privileges and immunities that should apply for inspectors and their documents.
- The inspection team expressed concerns that it should have adequate assurance that its health and safety is being protected. For the purpose of the exercise, appropriate guidance on health and safety was provided by the organisers. The inspection team request highlights, however, that inspection guidance should clarify how inspectors can be assured that local arrangements are adequate.
- The inspection team formed a view that at least two functional layers of C&S measures would be needed for them to gain adequate confidence of non-diversion when the accountable item was present in the dismantlement room. Inspectors considered that problems with the CCTV had undermined confidence in one of these layers and wished to apply additional sealing to compensate. The host team had a different perspective on this matter. A technical standard on such issues would normally be part of higher-level inspection guidance and should help to avoid disputes on such issues.
- Although many managed access restrictions were built into the procedures, they could not address all situations (e.g. the discussion on sealing of the dismantlement room door was

conducted on the spot by team leaders). Principles on how managed access should be negotiated need to be available.

33. To facilitate a shift from the very conceptual work of IPNDV to the very practical requirements of an inspection or exercise, the evaluators propose that IPNDV considers the nature and structure of guidance that would be needed to support a multilateral inspection and that this could be made clear for future exercises. For example, the elements of a framework might include:

- probable rights and obligations under a multilateral verification agreement, for example on access and managed access, as well as on issues such as the application of inspector privileges and immunities;
- approved inspection types and objectives (and generalised equipment requirements) that would be common to all inspected parties under a multilateral agreement;
- inspection performance standards and standard techniques and procedures;
- declaration and information sharing requirements, including information needed for effective inspection planning, such as facility design information and information on past inspection activities at a site;
- site-specific requirements agreed by the verification entity and inspected state, including agreed managed access and local escort rules and health and safety requirements.

Evaluation results: Interaction between the inspection and host teams

Inspector-host team dynamics

34. All players contributed to the NuDiVe exercise in a positive and professional way. At the same time, evaluators observed examples of competitive team dynamics that could come to impede the effective conduct of an inspection. Enforced separation of teams early in the exercise may have promoted a more adversarial culture, and evaluators saw examples of improved cooperation later in the exercise. Perceptions (on both sides) of a power imbalance between the teams was also a factor.

35. Formal meetings between the teams were business-like and focused on the practical implementation of the inspection. However, the meetings were not able to enter into more substantive discussions that may have enhanced interaction and improved inspection efficiency. Initially, the inspection team's limited knowledge of the controlled area was an impediment. Subsequently, the pressure to complete all activities within the week would have constrained discussions. The inspection and host team leaders agreed to regular additional meetings to try to improve the situation.

36. During activities in the controlled area, evaluators observed some examples of a very controlling approach by host team escorts. This may have been due to a combination of strict requirements in the behavioural rules related to safety and security, along with inexperience in host team members. Host players may have been anxious to avoid any mistake that could "expose sensitive information". They were often zealous in the application of rules about the movement of inspectors and on some occasions denied apparently reasonable inspector requests. Conversely, inspectors were passive and focused mainly on completing tasks according to procedures. The evaluators observed a few exceptions to this dynamic as confidence with the situation grew. A few inspectors convinced

escorts that an alternative methodology would be more efficient and some escorts showed flexibility after observing physical discomfort of inspectors in the Tyvek suits.

37. A number of comments in post-exercise questionnaires reflected on challenges raised by a power imbalance between the teams, for example the inability of the inspection team to handle their own radiation detection or C&S equipment. Such a perception may be inevitable for inspections at high security sites, but could colour the judgements that inspectors make with respect to confidence. IPNDV may wish to consider ways in which this problem could be managed.

38. Some player comments and evaluator observations reflected on the 1:1 ratio of host escorts to inspectors used during the exercise. Some felt that additional host escort could be needed, although this would have presented challenges due to the small size of some rooms.

Dispute management

39. Differences of view between the inspection and host team were managed respectfully. Not all disputes were resolved to the satisfaction of both sides, however. In part, this was due to time limitations in the exercise. The (understandable) artificiality of an exercise may also have been a factor. With limited information available to them about the larger context of verification requirements and national concerns, both host and inspection teams may have played to be competitive rather than to resolve a real problem. The fact that the exercise was a game may have led some players to discount the consequences of an unresolved dispute.

40. Artificialities aside, the evaluation team considers that much could be done to promote a cooperative culture, with both sides working toward a common purpose. Early and regular discussions between the teams (both formal and informal) about their respective objectives would be a useful step, but is of limited value unless both sides have an adequate understanding of the physical scenario. During NuDiVe, this detail only became clearer toward the end of the exercise. Some participants suggested that a future exercise might alternate host and inspector roles to find the most cooperative outcomes.

41. Of course, a cooperative inspection culture must still be one where trust is verified. It was appropriate that both host and inspections teams were cautious of the other, although caution should not become distrust without good reason.

42. Evaluators suggest that some of the disagreements that arose during the inspection might have been more easily addressed if the inspection activity was accompanied by a structured higher-level dialogue on the plans and objectives of each side in the inspection. Some such dialogue took place, but was largely ad hoc, leading the two team leaders to propose a regular meeting schedule. This proposal probably came too late in the exercise to be fully useful, however. Additional, but flexible, guidance on the need for routine meetings and on the purpose of those meetings could be developed by IPNDV and/or future exercise organisers.

Managed access

43. Numerous constraints on inspector access were of course built into the procedures applied during NuDiVe. However, the exercise also offered some opportunity to test negotiations on access to resolve a problem. One example was created by the organisers. Within the controlled area's

dismantlement room, there was a shrouded box and a tool box, neither of which could be opened for the inspection team nor sealed. There was an interesting discussion within the host team on access options, which highlighted the importance of tools to demonstrate that an item is "not a nuclear object". The inspection team did not pursue the issue, however, and appeared satisfied by a simple gamma detection test.

44. A robust negotiation on "access" did arise late in the inspection about the possibility of applying a seal to the door of the dismantlement room containing the declared item. Inspectors proposed this task following problems with some other elements of the C&S framework (i.e., CCTV and portal monitor), but the proposal was not agreed and the treaty item was returned to its original storage location.

Evaluation results: Overall assessment of inspection activities

45. Both inspection and host teams appeared satisfied that they had been able to do their job, even if time had prevented the actual completion of all steps. A significant challenge came from the details of the building (many diversion pathways, etc.) that may not be present for other locations, especially facilities that are purpose-built, or specially modified.

46. Evaluators and exercise participants consider that the exercise demonstrated that the applicable IPNDV-developed inspection concepts and approaches are sound. The detailed inspection procedures were clear and usable, but their application proved to be slow. Refinements (including as outlined in this report) should be considered. The application of a systems approach during inspections could do much to improve efficiency.

47. Inspection equipment employed in the exercise demonstrated its value. It was clear, however that failure of equipment, or doubts about its performance, could seriously undermine confidence. Significant work needs to be done not just to develop useful technologies that can support exercises, but also to produce systems that will be functional and reliable in the context of an inspection.

48. It should be recalled that NuDiVe has (understandably) been able to test only a limited part of inspection activities around dismantlement, although many lessons could have wider value.

Evaluation results: Assessment of the exercise scenario design, venue and organisation

49. Evaluators observed that the inspection approaches in steps 8.1, 8.3 and 8.4 (see Box 1) on verification of NED dismantlement developed by IPNDV were not explicitly referenced during the NuDiVe exercise. However they provided a basis for the procedures applied in the exercise. Also, the strategies ultimately pursued by the inspection team were, in the view of the evaluators, consistent with them. In this respect, NuDiVe has been effective for testing IPNDV thinking.

50. To date, much of IPNDV's work on tools and technologies for verifying nuclear weapon dismantlement has had a conceptual focus. Implementation of verification concepts in an exercise requires a significantly greater focus on detail. The NuDiVe exercise has made a critical new contribution to moving "from paper to practice", especially by testing a multilateral methodology. It has broadly affirmed IPNDV-developed concepts, but it has also highlighted some of the considerable challenges of moving from theory to practice. In the view of the evaluators, the single

biggest lesson to be addressed is that in implementing the detail of an inspection; efficiency and effectiveness will be aided by keeping strategic inspection objectives firmly in mind.

51. The inspection scenario developed by the exercise organisers, and the facilities offered by the Jülich Research Centre, added realism to the exercise. Within the unavoidably narrow scope of an exercise at this scale, they provided an excellent foundation for work.

Lessons for future exercises: Training

52. Artificialities in an exercise such as NuDiVe should be kept in mind when assessing its results. Few participants had prior training in application of the procedures nor the technologies, and most arrived without a clear strategy in mind. This could account for some of the problems and inefficiencies observed during the exercise. Indeed, it was evident that the pace of work improved as both inspectors and hosts gained experience with the procedures. NuDiVe included a helpful training element, but this could not be compared to the deep training provided to inspectors under existing arms-control and non-proliferation agreements. In many states, personnel facilitating inspections would have significant training also.

53. To get the best out of future gameplay exercises, playing teams should be more fully trained ahead of an exercise. The evaluators recommend that IPNDV considers how it may establish a cadre of experts with training in techniques and methodologies relevant to nuclear disarmament verification. Training could be organised in the period leading up to an exercise, but might also be done routinely (perhaps annually). Such training could also help to engage additional countries in work on nuclear disarmament verification and engage new experts in IPNDV's work. It would also help to maintain expertise, so that the lessons from exercises such as NuDiVe are not lost. An early step in this direction could be for IPNDV to prepare a list of relevant competencies for which a training program could be developed.

54. In terms of technical substance, however, many NuDiVe participants commented positively with respect to the training provided to them.

Lessons for future exercises: Exercise management

55. Many NuDiVe participants commented on some confusion in gameplay at the beginning of the exercise. The combined role of blue-shirted players as organisers, trainers, and host team support was a significant factor here. A statement by the organisers clarifying roles was helpful, but the inclusion of training in gameplay was problematic. Beginning the exercise after the training period should have helped to establish clear lines of communication between the inspection and host teams from the outset of the game. It would also have been better to formally make facility support personnel part of the host team.

56. Although the "free-play" principle is important in most exercises, there is also a need for active management by a control team if things go off track. The evaluators observed the emergence of a few problems during the exercise that might have been addressed more smoothly through an early intervention. A practice in other kinds of "field exercises" is for a control team to define a series of milestones for inspection progress along with possible injects to redirect play if necessary. Injects could also be "forced" if the control team wishes to test a particular question. In this respect, it is often the case that the host team leader works as an arm of the control team.

57. In addition to the inspection procedures, the organisers issued a document with “behavioural rules”. In the main, these rules addressed the conduct of gameplay as well as real-world safety issues. However, they also included guidance on inspector dress and behaviour that would have been better placed in the inspection procedures.

58. As noted earlier in this report, the guidance from which teams would work in an actual inspection would be wider than that used in NuDiVe. Both inspection and host teams often needed to create policy on certain issues as they went along. It appeared to evaluators that some host team members may have taken an overly cautious approach to inspector access because they did not know clearly what is sensitive and where they may have flexibility. Additional guidance for teams would be useful in future exercises so that each can work to a coherent strategy.

59. Evaluators noted that greater diversity among exercise players is key for better outcomes, both in terms of gender, professional expertise and countries represented.

Lessons for future exercises: Issues that could be tested in future exercises

60. The following are a number of comments and observations recorded by the evaluation team on potential areas for testing in future exercises:

a) An exercise could explore submission of declarations, inspection planning and notification, etc.
b) Exercising beyond step 8 in the 14-step process should be considered.
c) Equipment authentication/certification issues should be tested.
d) Further work on measurement techniques and information barriers could be useful.
e) Verifying design features of the dismantlement room, and sealing plans should be further explored.
f) Additional methods and tools for C&S measures should be considered.
g) Effort should be made to streamline or minimise time-consuming procedures.
h) Within the controlled area’s dismantlement room, there was a shrouded box and a tool box; neither can be opened nor sealed for the inspection team. The host team discussed options to allow the inspection team to satisfy itself that no nuclear item was hidden. This did not ultimately play out, likely due to time constraints. Managed access scenarios such as this should be tested.
i) Additional approaches could be tested for transferring data from a controlled area to inspection team offices.
j) Integrated and systematic use of surveillance devices should be examined.
k) Shift-change / rotation procedures could be improved/standardised.
l) Regarding the environmental samples, strict measures such as the whole body scanner are needed to keep security.

Concluding remarks

61. The NuDiVe exercise provided an excellent opportunity to tests concepts and approaches developed by IPNDV. Although the exercise focused on specific aspects of on-site inspections for verifying nuclear weapon dismantlement, many of the lessons will have wider application in relation

to IPNDV's 14-step process. The experience offers a potentially very useful basis for some work in IPNDV's phase III.

62. On the one hand, NuDiVe demonstrated that IPNDV's work on verification requirements for Step 8 (dismantlement) is heading in the right direction. It also brought into relief the many challenges of translating IPNDV's conceptual work into a regime that is practical and usable. It has offered a first opportunity for many IPNDV partners to engage in a gameplay exercise relevant to IPNDV's work.

63. The evaluators acknowledge the very significant efforts of the organisers to prepare for NuDiVe, including to make the Jülich facility available, to and to prepare the scenario, equipment, procedures and training. IPNDV could benefit significantly if at least part of this significant investment could be reused and built on in a follow-up to NuDiVe, or other future exercises.