INL/EXT-13-30222

PINS-3X Operations

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operated by Battelle Energy Alliance

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ABSTRACT

Idaho National Laboratory's (INL's) Portable Isotopic Neutron Spectroscopy System (PINS) non-intrusively identifies the chemical fill of munitions and sealed containers. The PINS-3X variant of the system is used to identify explosives and uses a deuterium-tritium (DT) electronic neutron generator (ENG) as the neutron source. Use of the system, including possession and use of the neutron generator and shipment of the system components requires compliance with a number of regulations. This report outlines some of these requirements as well as some of the requirements in using the system outside of INL.

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ACRONYMS

DOD	Department of Defense
DOE	Department of Energy
DT	Deuterium tritium
ENG	Electronic neutron generator
HPGe	High purity germanium
IED	Improvised Explosive Device
INL	Idaho National Laboratory
IND	Improvised Nuclear Device
NNSA	National Nuclear Security Administration
NRC	Nuclear Regulatory Commissiona
PINS	Portable Isotopic Neutron Spectroscopy
RDD	Radiological Dispersal Device
RGD	Radiation Generating Device
SNM	Special Nuclear Material

PINS-3X Operations

1. SYSTEM COMPONENTS

The PINS-3X[1] system consists of a mechanically-cooled high-purity germanium (HPGe) detector, a portable deuterium-tritium (DT) electronic neutron generator (ENG), system stand with associated shielding, laptop computer, battery box, and cables. A photo of the assembled system is shown in Figure 1.

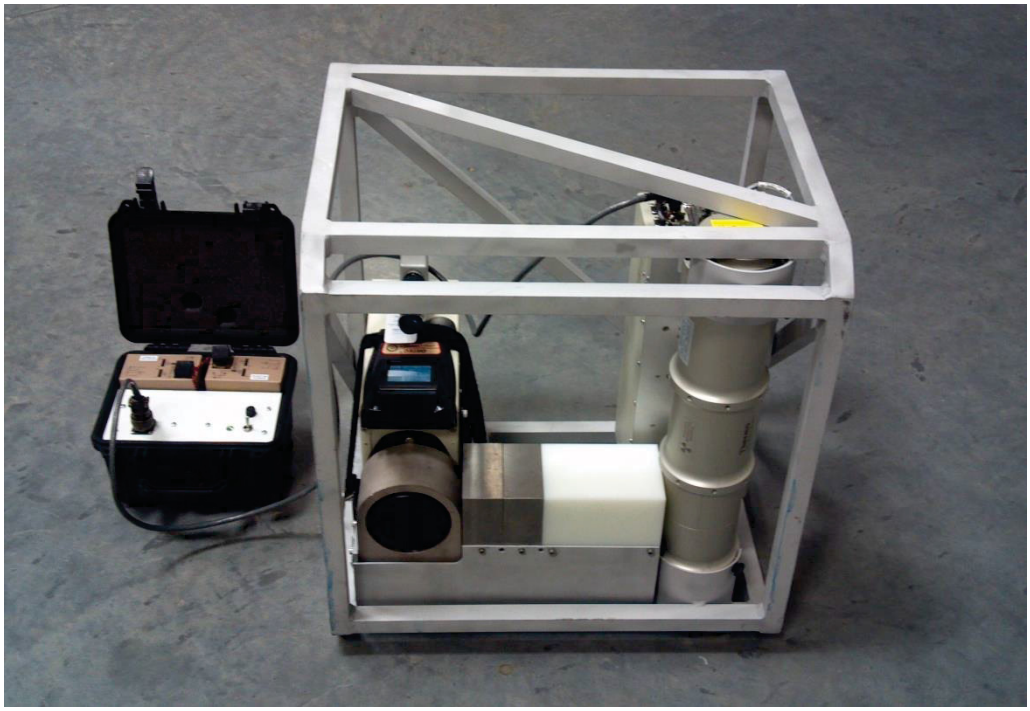

Figure 1: PINS-3X system

The system is packaged in a set of three shipping boxes shown in Figure 2. The largest box contains the system stand and battery box. The two smaller boxes contain the HPGe spectrometer and neutron generator, respectively. The large box contains the frame and shielding material. The weight of each component is listed in Table 1.

Figure 2: Shipping boxes

Table 1. Component weights

Component	Component weight (lbs)	Loaded shipping box weight (lbs)
HPGe	26	70
Neutron Generator	26	60
Stand & Shielding	100	150
Battery Box	5	
Laptop Computer	5	

1.1 Licensing Requirements for Components

The PINS-3X system does have some licensing requirements in order to be owned and operated. This is due to the tritium in the neutron generator. A valid Radioactive Material License by an appropriate regulating authority is required; this license must include a line item listing 3 Ci of tritium in the form of a sealed neutron tube. "Any Form" is also acceptable, provided that the regulating authority agrees that this also includes a sealed neutron tube. The regulating authority can be either the state government when the owner is located in an NRC Agreement State or the NRC itself. The neutron tube actually contains significantly less than 3 Ci of tritium, ensuring that the license will not be violated.

No other licensing is required to own or operate any of the other components of the PINS-3X system. The PINS+ software is export controlled, however, and an export license is required before exporting the software.

2. SHIPPING REQUIREMENTS

Shipment of the system using commercial shipping companies requires adherence to a number of regulations regarding the shipment of radioactive and hazardous materials. These requirements arise out of shipment of the neutron generator and the batteries for the battery box.

2.1 Neutron Generator Shipment

The neutron generator contains a solid metal hydride reservoir containing approximately 2 Ci of tritium. This amount of tritium, in this form factor, is regarded as an "excepted" quantity of tritium under NRC regulations[2]. The generator itself is marked as containing radioactive material as shown in Figure 3. The shipping label is marked as "THIS PACKAGE CONFIRMS TO THE CONDITIONS AND LIMITATIONS SPECIFIED IN 49 CFR 173.424 FOR EXCEPTED RADIOACTIVE MATERIAL, INSTRUMENTS AND ARTICLES, UN2911".

The generator is also a DOT-certified[3] pressure vessel. This allows it to be shipped by air and ground transport without removing the pressurized SF_6 insulating gas inside the generator but does add the requirement that the generator box be labeled as "SULPHUR HEXAFLUORIDE UN1080 NON FLAMMABLE GAS".

Figure 3: Radioactive material label

2.2 Battery Shipment

Both the HPGe spectrometer and the neutron generator are able to operate using either shore power (110 V AC) or batteries. The HPGe detector has an internal battery to provide power to the mechanical cooler that will last for up to two hours of operation. An additional external battery can be connected to the HPGe detector as shown in Figure 4 to provide an additional 6 or more hours of operation time for the detector. This battery has an approximate 200 Watt-hr capacity and can be held in the battery box that is included with the system. Similarly, the neutron generator can operate for approximately 8 hours using one of these batteries.

Figure 4: Detector with external battery

These large-capacity external batteries must be placed in UN Type 1A containers that are suitable for air transport for shipment. These containers can fit into the other shipping boxes that are equipped with the system. The batteries then have to be included in the shipper's "Declaration of Dangerous Goods" and require that cargo-only aircraft be used in the shipment. The internal batteries of the laptop computer and the TranSpec HPGe detector do not need to be removed from the equipment before shipment.

3. USE PERMITS

Use of the PINS-3X system requires a number of permits, depending on where and how the system is being used. As stated in an earlier section, ownership of the system by a non-DOE entity requires having a valid Radioactive Material License. Possession of such a license indicates that the owner has an appropriate radiological control program and has reviewed the activities where the radioactive material will be used. The sections below describe the two main uses of the system, namely emergency response and training or other routine use of the system.

3.1 Routine or Training Use of the System

The standard PINS system and the PINS-3X system have both been used at non-INL sites, both DOE sites and DOD sites. The requirements for use of the PINS-3X system at these sites has varied with the scope, with the operations, and the types of materials being assessed, i.e. whether live explosives, chemical warfare materiel, or real SNM were being assessed. There are two basic paths towards using the system at an outside site, namely either INL or another DOE owner controls and authorizes the use of the system and follows the necessary DOE protocols for its use, or the host site controls and authorizes the use of the system.

A recent example of a host site authorizing and controlling the use of a PINS-3X system is when INL conducted some tests using the system at Aberdeen Proving Ground in April and May of 2013. In April, a PINS-3X system was shipped to the Edgewood area of Aberdeen Proving Ground. Prior to shipping the neutron generator, an "Application for Army Radiation Authorization" form was submitted to the Army. This form indicated the type of radioactive source that would be shipped, the maximum dose rate that could be achieved by the generator running at full output, and details about the licensing of the radioactive material. A copy of this form can be seen in Appendix A. Once use of the generator was authorized by the U.S. Army, INL scientists and U.S. Army civilian employees could then operate the generator at Aberdeen Proving Ground while following U.S. Army radiological controls, radiological work permits, etc.

Alternately, the use, control, and regulation of the system could be completely controlled by the system owner at an off-site location. This type of scenario is particularly appropriate for training and demonstration activities. The owner of the system would then, with agreement by the host site, provide radiological control, dosimetry, radiological work permits, safety analysis, etc. This process is required if the host of the off-site location does not possess the necessary radiological control program to own a PINS-3X system. INL has provided off-site training using this process in the past, particularly in activities where SNM was used and INL needed to maintain control of the material. Activities involving use of the PINS-3X system can be similarly performed by the owner of the system, given that possessing the system requires an active radiological control program and a radioactive material license issued by the NRC or an agreement state.

3.2 Emergency Response Use of the System

The standard PINS system is periodically used for emergency response for identifying chemical warfare material or explosives at locations that are not U.S. Government property. Under such situations, transport and use of the system falls under the Military Munitions Rule[4] and some of the conditions required for transport and use of the system are relaxed in the interest of removing a threat to the general public in a timely fashion. The health physics training of the users and the operating guide of the instrument system is relied on in these circumstances. The Rule specifically does not include improvised explosive devices (IEDs), nuclear weapons, radiological dispersion devices (RDDs), or improvised nuclear devices (INDs).

Under situations where the PINS-3X system was being used in an emergency response to assess a suspected IND, IED, RDD, or nuclear weapon the NNSA team performing the response would similarly rely on the health physics training[5] of the operators and the operating guide of the instrument[6] . This is a similar procedure to how NNSA emergency responders operate some of their other Radiation Generating Device (RGD) gear such as x-ray radiography equipment. PINS operators are routinely trained in basic health physics concepts such as ALARA (As Low As Reasonably Achievable), radiation interactions in matter, and appropriate distances for radiation boundaries when using the system. This training would be used by the operators, along with their other training, in using the system safely.

4. CONCLUSIONS

PINS systems have been used at non-INL locations since their inception for emergency response, research and development, and training. Depending on the type of system, there are various requirements for ownership, shipment, and use of the system at other locations. The PINS-3X system incorporates a deuterium-tritium based electronic neutron generator, which requires licensing for the radioactive material and imposes some shipping requirements on the system. Awareness of these requirements allows a user to transport and operate the system safely and in an approved manner.

5. ACKNOWLEDGMENTS

We thank our INL colleagues Catherine Crowder and Sabrina Morgan for preparing the simulant chemicals used in the measurements, Ken Krebs for his assistance with gamma-ray spectral data analysis, John Zabriskie for mechanical design, Jayson Wharton for assistance in measurements, David Chichester for his advice on neutron generators, and finally Gus Caffrey for his advice on PGNAA and PINS. We also thank our colleague Robert Maddox of the U.S. Army CBRNE and Remediation Activity (CARA) for his advice on emergency PINS use.

PINS research is supported under U.S. Department of Energy Field Office, Idaho contract number DE-AC07-05ID14517.

References

[1] A.J. Caffrey et al., "Chemical Warfare Agent and High Explosive Identification by Spectroscopy of Neutron-Induced Gamma-Rays", IEEE Transactions on Nuclear Science **39** (1992) pp 1422-1426.

[2] "Table of Activity Limits" 49 CFR 173.425 (2012).

[3] DOT Special Permit DOT SP-13181, available for download at http://www.phmsa.dot.gov/staticfiles/PHMSA/SPA_App/OfferDocuments/SP13181_2007020096.pdf

[4] Military Munitions Rule 40 CFR 260, *et seq*.

[5] Kent Gray, Radiological Assistance Program (RAP) Region-4 Region Coordinator (personal communication, Sep. 2013)

[6] PINS-3 Explosive Identification System User's Manual, Idaho National Laboratory (2013).

APPENDIX A
Application for Army Radiation Authorization

APPLICATION FOR ARMY RADIATION AUTHORIZATION

For use of this form, see AR 11-9; the proponent agency is DAS

1. THIS IS AN APPLICATION FOR *(Check appropriate item)*	2. NAME, MAILING ADDRESS, AND E-MAIL ADDRESS OF APPLICANT *(Include ZIP Code)*
[X] NEW ARA [ ] AMENDMENT TO ARA NUMBER _____ [ ] RENEWAL OF ARA NUMBER _____	Edward H. Seabury, Idaho National Laboratory PO Box 1625, Idaho Falls, ID 83415-3740 Edward.Seabury@inl.gov

3. ADDRESSES WHERE AUTHORIZED IONIZING RADIATION SOURCES WILL BE USED OR POSSESSED

ATTN: AMSRD-ECB-CB-CO, U.S ARMY RDECOM
E-3832/George Smith, Aberdeen Proving Ground
Edgewood, MD 20101

4. NAME OF PERSON TO BE CONTACTED ABOUT THIS APPLICATION	5. TELEPHONE NUMBER AND FAX NUMBER
Mr. Gary Wright, RDECOM, Radiation Safety Officer at ECBC Aberdeen Proving Ground, Gary.W.Wright@us.army.mil	TEL: (410) 436-2286

Items 6 through 12 may be continued on the following page or on 8 1/2 x 11 inch paper. The type and scope of information to be provided should be adequate to show complete compliance with applicable regulations and guidance. *(If you can link use of radioactive material to a valid Nuclear Regulatory Commission (NRC) license, provide number and expiration date of the license and only submit items that differ from the NRC license application and associated documents.)*

6. RADIATION SOURCE(s)

a. RADIOACTIVE MATERIAL *(Element and mass number, chemical and/or physical form, and maximum amount that you will possess at any one time.)*	b. ACCELERATOR(s) AND X-RAY SYSTEM(s) CAPABLE OF PRODUCING A "HIGH RADIATION AREA" OR "VERY HIGH RADIATION AREA" *(Describe)*
Hydrogen-3 (tritium), sealed source by Thermo MF Physics Corporation (Model A-3062) (SSDR: CO-1012-D-101-S) in the form of solid metal hydride, Max. activity	See Continuation Section

7. PURPOSE(s) FOR WHICH IONIZING RADIATION SOURCE(s) WILL BE USED	8. INDIVIDUAL(s) RESPONSIBLE FOR RADIATION SAFETY PROGRAM AND THEIR TRAINING AND EXPERIENCE
To generate neutrons for the PINS system for active neutron interrogation of chemical agent munitions to identify munition fill materials.	Ms. Chere Morgan, Radiological Control Director, Idaho National Laboratory
9. TRAINING FOR INDIVIDUALS WORKING IN OR FREQUENTING RESTRICTED AREAS	10. FACILITIES AND EQUIPMENT *(Describe rooms or areas, sheidling, safety devices, monitoring equipment, and so on.)*
All operators of the neutron generator are either trained radiation workers, in accordance with the U.S. Department of Energy Radiation Worker II training program or trained PINS operators.	See Continuation Section
11. RADIATION SAFETY PROGRAM	12. WASTE MANAGEMENT
See Continuation Section	No radioactive waste will be generated.

13. CERTIFICATION

The applicant understands that all statements and representations made in this application are binding upon the applicant. The applicant and any official executing this certification on behalf of the applicant, named in Item 2, certify that all information contained in this application is true and correct to the best of their knowledge and belief.

14. NAME, RANK, AND TITLE OF CERTIFYING OFFICER	15. SIGNATURE
Edward H. Seabury, Ph.D. Nuclear Physicist Idaho National Laboratory	16. DATE *(YYYYMMDD)*

DA FORM 3337, MAY 1999 DA FORM 3337, MAR 80, IS OBSOLETE APD V1.00

ITEMS 6 THRU 12 *(Continued)*

6b. The A-3062 sealed source of 6a. is a sub-part of a model MP320 neutron generator, also manufactured by Thermo MF Physics Corporation. The MP320 neutron generator is a portable particle accelerator, cylindrical in shape, which produces neutrons with an energy of 14.1 MeV as a result of the $^{2}H + ^{3}H$ nuclear fusion reaction. The neutron generator is capable of producing $1x10^{8}$ neutrons per second.

The calculated dose rate vs. distance curve of a 1×10^{8} n/s neutron generator is compared the curve for a standard PINS Cf-252 source in Figure 1 below.

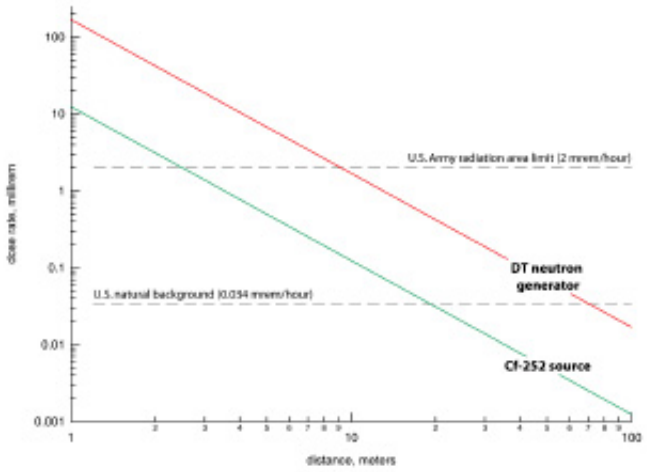

Figure 1. Dose rate vs. distance from PINS Cf-252 source and DT neutron generator.

During operations the MP320 creates a 100 mrem/hr dose field at 1.3 m from it's centerline, this dose field decreases with roughly a r^{-2} relationship from the center of the instrument. Therefore, the MP320 produces a high radiation field out to 1.3 m from the device centerline. The neutron generator dose rate falls below 1 mrem/hour

The MP320 does not generate a very high radiation field.

10. The MP320 neutron generator is an electrical instrument and does not produce radiation when de-energized.
It does not require external shielding of special facilities. Prior to operation, a controlled area of approximately 10 m radius will be setup to create a 2 mrem/hr perimeter using a rope or tape barrier and appropriate postings. Operators will run the unit from outside the controlled area using a laptop computer and wire cable connected to the system.

The instrument incorporates a remote interlock switch for de-energizing the system and a flashing red lamp light to indicate when the system is energized. The interlock switch is co-located with the laptop computer. and is connected to the neutron generator using a cable.

11. Idaho National Laboratory (INL) is an U.S. Department of Energy facility and hence it is exempt from NRC licensing under the provisions of 10CFR30.12. INL maintains a Radiological Control Program in accordance with 10 CFR 835 and DOE Policy 441.1. We will operate the unit in accordance with our radiation safety program and will adhere to radiation safety procedures and requirements at the Edgewood Area, Aberdeen Proving Ground.