Technical Basis for the International Export of Handheld Spectroscopy Detectors for Safeguards Applications

The international export of handheld spectroscopy detectors by the National Nuclear Security Administration (NNSA) to partner states will provide state regulatory authorities and nuclear material owners a way to improve accountancy for accidental gains of nuclear material, including the provision of reports to the IAEA, in order to meet their safeguards agreements.

International Atomic Energy Agency (IAEA) safeguards agreements for non-nuclear weapons states requires accountancy for all nuclear material. As defined in Article XX of the IAEA statute, nuclear material includes source materials: "uranium containing the mixture of isotopes occurring in nature," and special fissionable material: "plutonium-239; uranium-233; uranium enriched in the isotopes 235 or 233"[1]. For IAEA Member States to meet their requirements under comprehensive safeguards agreements (CSA), safeguards are to be applied on "all source or special fissionable material," which "includes all nuclear material subject to IAEA safeguards"[2]. Therefore, accidental gains and losses of nuclear material must be reported to the IAEA. An accidental gain occurs when a state unexpectedly adds nuclear material to their inventory by various means such as seizing smuggled material or the discovery of legacy items previously unaccounted for. The material type and quantity must be added to the State's inventory by updating domestic records and then communicated to the IAEA[3].

Gamma spectroscopy detectors are widely used in safeguards, security, and safety practices. The FLIR HM-5 handheld radiation spectroscopy device is commonly used by IAEA inspectors to verify nuclear material inventories. This radionuclide identification device is based on scintillation technology. It has the capability to search for uranium, plutonium, and thorium bearing materials, identify present isotopes, determine levels of uranium enrichment, and verify active fuel length of nuclear fuel[4]. The HM-5 is specifically made for the IAEA and is not commercially available, however, the FLIR identiFINDER-R400 is the commercially available version of the HM-5. The identiFINDER-R400 is produced in many variations (i.e. R400 NGH, R400 UCLS-NGH, R400 ULK-NG etc.) and is used to detect and characterize radioactive material in various applications[5].

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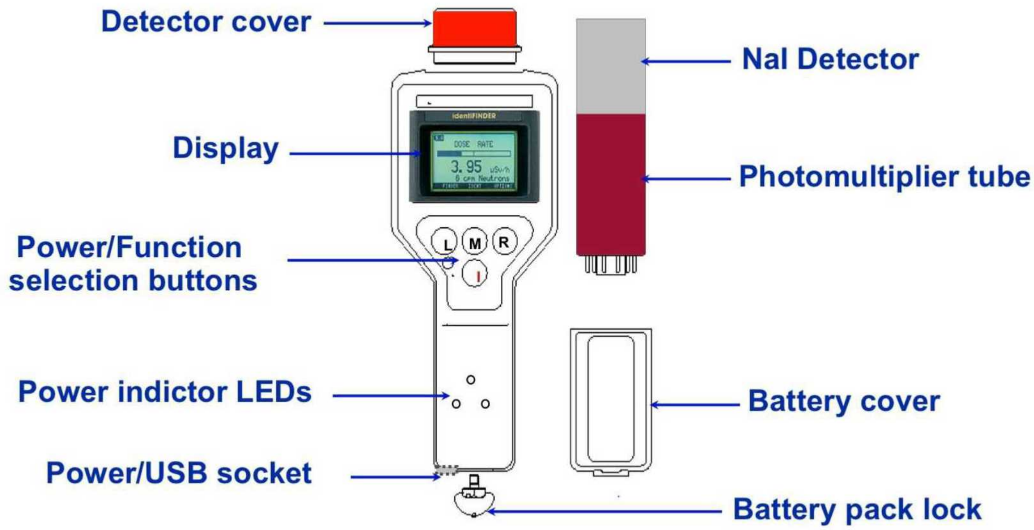
[1] (International Atomic Energy Agency n.d.)
[2] (International Atomic Energy Agency n.d.)
[3] (International Atomic Energy Agency 2016)
[4] (Schanfein 2013)
[5] (FLIR 2019)

Sandia National Laboratories is a multimission laboratory managed and operated by National Technology & Engineering Solutions of Sandia, LLC, a wholly owned subsidiary of Honeywell International Inc., for the U.S. Department of Energy's National Nuclear Security Administration under contract DE-NA0003525.

Figure 2: Labeled



components of an HM-5/identiFINDER

In April of 2016, Georgia reported the accidental gain of nuclear material when it was seized during a presumed smuggling destination of Turkey. The seized material was detected by an identiFINDER-R400 and described as “small in quantity, but huge in potential consequences, if ever used with malevolent intent”[6]. This incident was deterred in part because of the “longtime American technical assistance”[7], which includes providing the state with instruments like radiation detectors.

In December of 2019, a crime group was apprehended in Vienna, Austria for the smuggling of nuclear materials. The smugglers were attempting to sell an item allegedly containing enriched uranium but were stopped due to a transnational effort. This case demonstrates the need for radiation detectors capable of the identification of nuclear materials, especially as conflict zones make radiological and nuclear material sources vulnerable and the opportunity for illicit trafficking remains[8].

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6 (Edilashvili 2016)
7 (Edilashvili 2016)
8 (Europol 2019)

Figure 1: Detectors, like in the identiFINDER-R400 series, can detect neutron or gamma radiation emitted from nuclear materials.

The identiFINDER-R400 is a user-friendly device designed for all-purpose surveying, responding to emergencies, and environmental monitoring. According to FLIR, this device, "reduces training time and costs, while increasing operator confidence and inter-operability between agencies using FLIR products" and as a result, there are "over 20,000 devices deployed globally"[9]. The identiFINDER-R400 has a Sodium Iodide (NaI) scintillator detection capabilities for obtaining gamma-ray spectra, a Geiger-Muller tube for measuring dose rates and certain variations have as well as an He^3 tube for neutron detection. Several radionuclides can be listed at a time upon being identified.

The spectral data processing algorithm used by identiFINDER-R400 provides the characterization capabilities necessary for reporting the nuclear material element type associated with an accidental gain to the IAEA. By allowing state operators a way to report these domestic accidental gains, identiFINDER-R400s also allows CSA requirements to be met. The National Nuclear Security Agency's International Nuclear Safeguards Engagement Program supports the FLIR identiFINDER-R400 as an efficient and effective device to provide other states with for the purpose of nuclear material identification to reinforce IAEA safeguards reporting.

Internationally, there has been great importance placed on nuclear issues as stated by the Treaty on the Non-Proliferation of Nuclear Weapons which supports nuclear disarmament, non-proliferation, and the peaceful use of nuclear energy[10]. Supporting IAEA Member States by exporting FLIR identiFINDER-R400s to state regulatory authorities and operator programs strengthens a state's safeguards and the international safeguards regime, such as proposed in the given cases, by providing a state the means to identify types of nuclear material and thus improving gains reporting by IAEA Member States.

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[9] (FLIR 2019)
[10] (International Atomic Energy Agency n.d.)

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ANNEXES

HANDHELD SPECTROSCOPY DETECTOR SPECIFICATIONS

These Annexes offer further insight on the FLIR HM-5 and FLIR identiFINDER-R400. Annex A and B provide separate specifications of the HM-5 and the identiFINDER-R400 wherein details of each model's features and software can be reviewed. A brief comparison is then provided in Annex C to identify pertinent differences.

ANNEX A – HM-5 Specifications
ANNEX B – IdentiFINDER-R400 Specifications
ANNEX C – Brief Insight on Differences between the HM-5 and IdentiFINDER-R400

ANNEX A – HM-5 Specifications

Item	Description
1. FLIR instrument model	• IdentiFINDER-R400 • ULCS-TNG (with Cs-137 check source) • Source is exempt from transportation regulations
2. Scintillation (NaI) detector	• NaI (Tl): 23-mm diameter; 21-mm thick • Measurement range: ~0.010 μSv/h to ~500 μSv/h • Gamma energy range: ~20 keV to 3 MeV (1024 channels)
3. Geiger-Muller (GM) detector	• Measurement range: ~100 μSv/h to 10 mSv/h • Auto-switch to GM detector: ~250 to ~ 500 μSv/h • When GM detector active, banner appears in title bar • GM detector is side-mounted in case; aligned with red dot
4. Detector energy calibrations	• Instrument contains ~ 500 Bq source of Cs-137 • Source affixed to front face of detector
5. Spectrum stabilization	• Light-emitting diode (LED)
6. Field use conditions	• Operating temperature: -20° C to +55° C • Avoid exposing detector to sudden temperature changes • Relative humidity: 10% to 80% (non-condensing)
7. Bluetooth	• Disabled
8. GPS	• Disabled
9. Neutron detector	• Not installed in the HM-5 model

(International Atomic Energy Agency 2016)

ANNEX B – IdentiFINDER-R400 Specifications

Item	Description
1. FLIR instrument model	• Radionuclide identification device (RID) • Variants – NG[1], NGH[2], UW-NG[3], UW-NGH[4], LG[5], LGH[6], UW-LG[7], UW-LGH[8], T1[9], T2[10]
2. Scintillation (NaI) detector	• Gamma (NaI)[1-4]: 35 x 55 mm, Gamma (NaI) Tungsten Shielded[9,10]: 23 x 21 mm, Gamma (LaBr3)[5-8]: 30 x30 mm • ANSI N42.34 library • Measurement range: 0 nSv/h to 500 µSv/h. • Gamma energy range: 20 keV to 3 MeV (1024 channels)
3. Geiger-Muller detector	• Measurement range: 100 µSv/h to 10 mSv/h
4. Detector energy calibrations	• N/A
5. Spectrum stabilization	• Variants[1-4] – calibration source • Variants[5-8] – LED
6. Field use conditions	• Operating temperature: -20° C to 50° C • Avoid exposing detector to sudden temperature changes • Relative humidity: 10% to 80% (non-condensing)
7. Bluetooth	• On-board Bluetooth
6. GPS	• Removable
7. Neutron detector	• HE^3 tube[2,4,6,8,10]:15x54mm • Neutron Sensitivity[2,4,6,8,10]: 2.6 cps/nv; ± 20% • Detects neutron or gamma radiation emitted from natural occurrences in the environment, special nuclear material, industrial, or medical material

(FLIR 2019)

ANNEX C – Brief Insight on Differences between the HM-5 and IdentiFINDER-R400

Characteristics	HM-5	identiFINDER-R400
Attribute test for U, Pu, and Th materials	Based on statistics	Has a library lookup with non-statistical confidence level (ANSI N42.34 library)
Distinguish between natural (0.7% U-235), depleted (ca. 0.2% U-235), LEU (0.7 – 20% U-235), and HEU (> 20% U-235)	Utilizes uranium sources to calibrate the device for enrichment	
Active length determinations	Verification of active length of nuclear fuel	