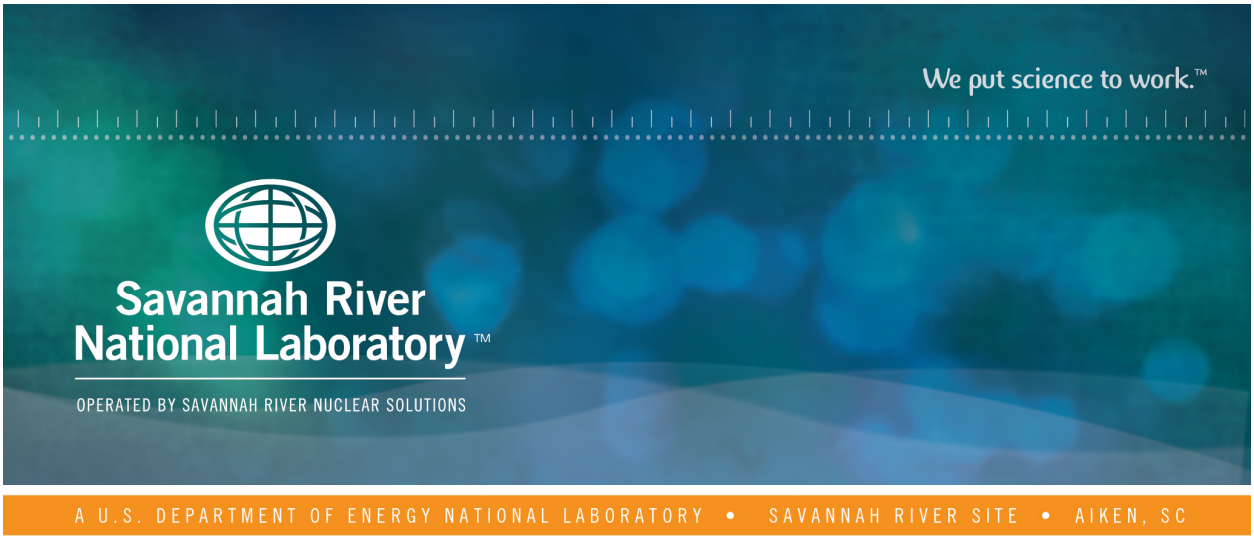

Validation of ANSI N42.34 – American National Standard Performance Criteria for Hand-Held Instruments for the Detection and Identification of Radionuclides

August 2014

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DISCLAIMER

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Validation of ANSI N42.34 – American National Standard Performance Criteria for Hand-Held Instruments for the Detection and Identification of Radionuclides

August 2014

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Savannah River National Laboratory™
OPERATED BY SAVANNAH RIVER NUCLEAR SOLUTIONS

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PREFACE

This document is an evaluation report from the Savannah River National Laboratory (SRNL) of an evaluation of ANSI N42.34-D6, *American National Standard Performance Criteria for Hand-Held Instruments for the Detection and Identification of Radionuclides*. Assessments of Section 5 (Design), Section 6 (Radiological tests), and 10 (Documentation) were performed at SRNL's Health Physics Instrument Calibration Laboratory. Assessments of Section 7 (Environmental performance requirements), Section 8 (Electromagnetic performance requirements), and Section 9 (Mechanical performance requirements) were performed at Qualtest, Inc. in Orlando, Florida.

The radionuclide identification device (RID) selected by SRNL for this validation effort was the identiFINDER® 2, manufactured by FLIR Radiation.

EXECUTIVE SUMMARY

SRNL's validation of ANSI N42.34-D6 for the Domestic Nuclear Detection Office (DNDO) was performed utilizing one hand-held instrument (or RID) – the FLIR identiFINDER 2. Each section of the standard was evaluated via a walk-through or test. **NOTE:** In Table 1, W = walk-through and T = test, as directed by the Domestic Nuclear Detection Office (DNDO). For a walk-through, the experiment was either setup or reviewed for setup; for a test, the N42.34-D6 procedures were followed with some exceptions and comments noted.

SRNL is not fully able to evaluate a RID against Sections 7 (Environmental), 8 (Electromagnetic), and 9 (Mechanical) of N42.34, so those portions of this validation were done in collaboration with Qualtest, Inc. in Orlando, Florida. The walk-throughs and tests of Sections 7, 8, and 9 were performed in Qualtest, Inc. facilities with SRNL providing radiological sources as necessary.

Where applicable, assessment results and findings of the walk-throughs and tests were recorded on datasheets and a validation summary is provided in Table 1. A general comment pertained to test requirements found in another standard and referenced in N42.34-D6. For example, step 1 of the test method in section 8.1.2 states "RF test set up information can be found in IEC 61000-4-3." It is recommended that any information from other standards necessary for conducting the tests within N42.34 should be posted in N42.34 for simplicity and to prevent the user from having to peruse other documents. Another general comment, as noted by Qualtest, is that a tolerance reference is not listed for each test in sections 7-9.

Overall, the N42.34-D6 was proven to be practicable, but areas for improvement and recommendations were identified for consideration prior to final ballot submittal.

Table 1. Summary of the SRNL Validation of ANSI N42.34.

Section	Description	Validated		Comments
		W	T	
1	Scope	X		None
2	Purpose	X		None
3	References	X		None
4	Definitions and General Considerations			
4.1	Definitions	X		None
4.2	General considerations	X		None
4.3	Standard test conditions	X		None
4.4	Units and uncertainties	X		None
4.5	Special word usage	X		None
5	Design			
5.1	General	X		None
5.2	Test preparation		X	None
5.3	Access modes		X	None
5.4	Markings		X	None
5.5	Data transfer interface		X	None

Section	Description	Validated		Comments
		W	T	
5.6	User interface		X	The level for the backlight intensity of a RID under evaluation is not specified. *Recommendation:* Consider inserting a statement "If adjustable, ensure the backlight of the RID is set to maximum intensity during evaluation" to the test method.
5.7	Visual indicators		X	Unsure if most RIDs would display a radionuclide that cannot be identified as "not identified" or "unknown." The RID tested displayed "unknown" if radioactive material was present but the radionuclide could not be identified. *Recommendation:* Consider adding "unknown" to the list of possibilities for when a radionuclide cannot be identified.
5.8	Supervisory user accessible indications and functions		X	None
5.9	Audio indicators		X	None
5.10	Warm-up time		X	None
5.11	Battery power		X	None
5.12	Effective range of measurement		X	None
5.13	Data file configuration		X	None
5.14	Personal protection alarm		X	None
5.15	Explosive atmospheres	X		None
6	Radiological tests			
6.1	General test method		X	None
6.2	False alarm		X	*Recommendation:* Make the acceptability criteria consistent within the section – 2 alarms within a 5 h period.
6.3	Photon alarm		X	Section makes reference to an equation in 6.1.4, but no equation appears there. Also, this section provides clear instructions and figure of the test setup, however the reasoning behind the 10 μR/h above background requirement is unclear, especially with the "low exposure rate" statement in 6.1.4. *Recommendation:* If an equation is to be included in section 6.1.4, then state the equation. Make the requirement 50 μR/h above background (as in section 6.8).
6.4	Neutron alarm		X	No tests were performed as the RID tested did not have neutron indication capabilities. SRNL can perform this section's test requirements.
6.5	Exposure or ambient dose equivalent rate accuracy		X	None

Section	Description	Validated		Comments
		W	T	
6.6	Over-range test		X	No tests were performed due to the high exposure rates necessary for this section. SRNL can perform this section's test requirements.
6.7	Neutron indication in the presence of photons	X		No walk-through was performed as the RID tested did not have neutron indication capabilities. SRNL can perform this section's test requirements.
6.8	Radionuclide identification		X	Performed tests of section 6.8.3 (Single radionuclide identification) at 50 μR/h above background (as stated in TCS) and at 10 μR/h above background (per DNDO request).
6.9	Simultaneous radionuclide identification		X	No issues were identified with removing NOTE 2 from 6.9.2 of standard (as mentioned in a comment in N42.34-D6, section 6.9.2). Difficult to test since NORM surrogates were unavailable (used a smoke detector (Ra-226) and welding rods (Th-232) for testing. *Recommendation:* Provide each NVLAP accredited laboratory with NORM surrogates for test projects.
6.10	False identification		X	The tested RID displayed "Unknown" for each trial. Have seen other RIDs display "Background" in these conditions (background < 25 μR/h). Unclear if "Unknown" would be considered acceptable.
7	Environmental performance requirements			
7.1	Ambient temperature requirements	X		It is unclear if access to the test item (RID) is required during the test and what should be done if the temperature varies (e.g., inner chamber temperature could change if the door was opened at any time). *Recommendation:* Consider stating the temperature tolerance(s) in the test method.
7.2	Temperature shock	X		Same *Recommendation* as 7.1
7.3	Relative humidity (RH)	X		Same *Recommendation* as 7.1. Also, edit step 12 of the test method to read "Following the 2 h stabilization period, return the temperature to 22°C at the 10°C/h rate *while maintaining 40% RH* and after a 2 h stabilization period…"
7.4	Dust and moisture protection	X		*Recommendation:* If all dusting mediums are considered equivalent by the standards or test agencies, then allow use of other dusting mediums (i.e., red china clay, silica) that are more commonly utilized than talcum powder.
7.5	Extreme temperature startup	X		None

Section	Description	Validated		Comments
		W	T	
8	Electromagnetic performance requirements			
8.1	Radio frequency (RF)	X		*Recommendation:* Consider frequency range 80 MHz – 6000 MHz rather than 80 MHz – 2500 MHz. Also, consider making the field intensity requirement 10 V/m over the entire frequency range tested.
8.2	Radiated emissions	X		The basis for the 50 kHz bandwidth is unclear (non-standard bandwidth that may not be available on all analyzers used to perform emissions testing). Also, most labs are not capable of testing at 3 m. *Recommendation:* Given the frequency range specified, use a 100/120 kHz bandwidth selection (120 kHz preferred). Allow for testing at 1 m versus 3 m.
8.3	Magnetic field	X		None
8.4	Electrostatic discharge (ESD)	X		None
9	Mechanical performance requirements			See Results and Discussion
9.1	Vibration	X		*Recommendation:* Define an axis of orientation for a RID and establish a dedicated vibration/shock fixture for a RID to the test equipment for repeatable tests.
9.2	Mechanical shock	X		*Recommendation:* Consider subjecting the RID to three shocks in each direction of each axis (18 total shocks).
9.3	Impact (microphonics)	X		No walk-through was performed as Qualtest does not possess equipment identified.
9.4	Drop	X		*Recommendation:* Clarify how the test can be controlled to ensure the RID does not topple after the drop.
10	Documentation			
10.1	Report	X		None
10.2	Operation and maintenance manual	X		None
	Annex A	X		None
	Annex B	X		None
	Annex C	X		None

If a comment is listed in the Comments column of Table 1 for a particular section, further description is available in the Results and Discussion segment of this document.

TABLE OF CONTENTS

1.0 Introduction

The ANSI N42.34 standard contains performance specifications and testing methods for the evaluation of hand-held instruments (otherwise known as RIDs) for the detection and identification of radionuclides that emit gamma rays and, if applicable, neutrons. With the latest copy of the standard (N42.34-D6) sent for ballot, DNDO requested for SRNL to perform a validation of the standard. This document provides the results of that validation.

As indicated in Table 1, certain sections of the standard were evaluated via a "walk-through" (labelled "W") and others were tested (labelled "T"). "Walk-through" means the section was read and the test was either setup or reviewed for setup, but performance of the test did not occur. For those sections tested, the instructions in N42.34-D6 were followed to the extent possible and the results and any comments/observations were recorded on datasheets, which are provided with the submission of this report.

The RID selected by SRNL for this validation effort was the identiFINDER 2, manufactured by FLIR Radiation. This particular RID was a gamma-only instrument and did not possess neutron detection capabilities. Thus, datasheets for Sections 6.4 and 6.7, which pertain to neutrons, are not included with the other datasheets.

Figure 1. The identiFINDER 2

SRNL is not fully able to evaluate a RID against Sections 7 (Environmental), 8 (Electromagnetic), and 9 (Mechanical) of N42.34, so those portions of this validation were done in collaboration with Qualtest, Inc. in Orlando, Florida. The walk-throughs and tests of Sections 7, 8, and 9 were performed in Qualtest, Inc. facilities with SRNL providing radiological sources as necessary.

2.0 Experimental Procedure

2.1 Testing

The experimental procedures for this validation were as prescribed in the N42.34 standard using direction from the DNDO on whether a particular section was to be a "walk-through" or a "test." The User Manual for the identiFINDER 2 was consulted as needed.

2.2 Datasheets

Datasheets were developed by SRNL to record the test data, including any data collected during the validation of sections 7, 8, and 9 at Qualtest, Inc. Datasheets were not completed (or partially completed) as part of this validation for the following sections: 1, 2, 3, 4 (4.1 – 4.5), 5.1 and 6.1 (General), and 6.4 and 6.7 (pertaining to neutrons), 7.2, 7.3, 7.5, 8.1, 9.2, 9.3, and 9.4.

3.0 Results and Discussion

All test results were recorded on datasheets and some comments are summarized in Table 1. Further observations and comments for individual sections of the standard are described here.

Section 5.6 – User interface: The display settings for the identiFINDER 2 are adjustable – daytime, nighttime, or classic settings for the color of the display and the intensity for the backlight ranges from 0 (no backlight) to 10 (very bright). There is no mention in section 5.6 of what the backlight intensity of the tested RID should be during evaluation. Consider inserting a statement "If adjustable, ensure the backlight of the RID is set to maximum intensity during evaluation" to the test method. SRNL conducted the validation tests of this section at the maximum backlight intensity level (10) and "daytime" color display of the RID.

Section 5.7 – Visual indicators: The requirements of this section state that the display of the RID shall provide an indication when a radionuclide cannot be identified (e.g., "not identified"). For the identiFINDER 2, if an isotope is not present in the nuclide library, then "Unk" (Unknown) was displayed. This is an indication that the RID is capable of detecting that some radiological "material" may be present, but cannot determine the identity. Consider changing "not identified" to "unknown."

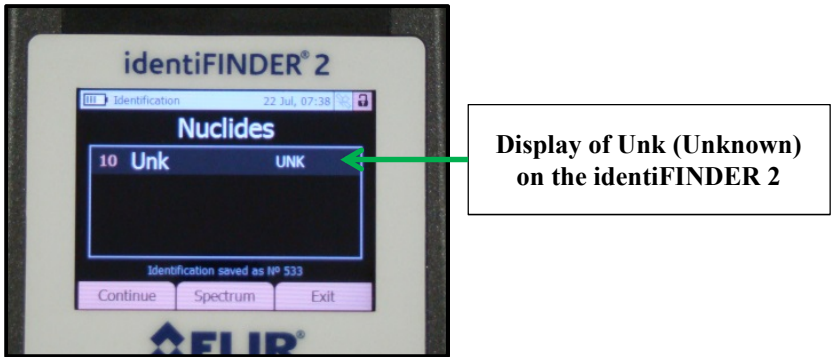

Figure 2. Display of an Unknown Identified Isotope

Section 6.2 – False alarm: The requirements of this particular section state "the alarm rate providing an indication of radiation field changes shall be less than 1 alarm over a period of 1 h when tested in an area with a stable background." However, later in the test method, it is stated "the results are acceptable if

there are no more than 2 alarms during the 5 h period." SRNL observed the identiFINDER 2 for 5 hours for this test. Recommend making consistent within the section – 2 alarms within a 5 h period.

Section 6.3 – Photon alarm: Statements in section 6.1.4 of the standard convey the difficulty of using an instrument (RID) to measure low exposure rates, e.g., 50 μR/h. The requirements listed in 6.3.1 are to establish the source to detector distance that provides an exposure rate of 10 μR/h above background at the reference position of the RID using the equation from section 6.1.4. First, no equation appears in section 6.1.4 of N42.34-D6. Second, SRNL does not understand the reasoning for using 10 μR/h above background for this test rather than 50 μR/h. Consider making the test requirement 50 μR/h for better RID response and consistency (stated as 50 μR/h above background in section 6.8). SRNL conducted the validation tests of this section with the source to detector distance for 10 μR/h above background (results recorded on datasheets).

Section 6.4 – Neutron alarm: This section was not applicable as the particular RID tested did not have neutron indication capabilities – other variants of the identiFINDER 2 are equipped with neutron detectors. SRNL has the competency to perform this section's test requirements.

Section 6.6 – Over-range test: The manufacturer-stated maximum exposure rate for the identiFINDER 2 was 1000 mR/h. Due to the high exposure rates required for this section, these tests were not performed as part of this validation. SRNL has the competency to perform this section's test requirements.

Section 6.7 – Neutron indication in the presence of photons: This section was not applicable as the particular RID tested did not have neutron indication capabilities. SRNL has the competency to perform this section's test requirements.

Section 6.8 – Radionuclide identification: The test methods listed in section 6.8.3.2 state "the source to reference point distance needed to produce 50 μR/h above background." SRNL conducted the tests with the following sources: Co-60, Ba-133, Cs-137, Ra-226, Th-232, Am-241, DU, HEU, and WGPu. At the request of DNDO, the tests were repeated with the same sources but at a source to reference point distance to produce 10 μR/h above background.

Section 6.9 – Simultaneous radionuclide identification: SRNL agrees with the deletion of NOTE 2 from 6.9.2, if desired (as mentioned in a comment in N42.34-D6, section 6.9.2). Also, tests involving NORM were difficult for this section since SRNL is not in possession of NORM surrogates. SRNL utilized available ^{226}Ra and ^{232}Th sources, a smoke detector and welding rods, respectively, for these validation tests. Consider eventually supplying all NVLAP-accredited laboratories with NORM surrogates for testing requirements.

Section 6.10 – False identification: The identiFINDER 2 displayed "Unknown" for each trial. It has been observed in other RIDs a display of "Background" or a NORM isotope in these test conditions – background < 25 μR/h. Section 6.10.2 states "the results are considered acceptable when the RID does not identify a radionuclide or indicates that an identification is not possible in nine out of ten trials." It is unclear whether the display of "Unknown" is considered a pass or a fail, per the scoring criteria. Consider making "Unknown" or "Background" an acceptable result.

Observations and comments on sections 7-9 of N42.34 are directly from Qualtest, Inc.

Section 7.1 – Ambient temperature influence: It is unclear if access to the test item (RID) is required during the test and what should be done if the temperature varies (e.g., inner chamber temperature could

change if the door was opened at any time). Consider stating the temperature tolerance(s) in the test method.

Section 7.2 – Temperature shock: Same comments as section 7.1.

Section 7.3 – Relative humidity (RH): Same comments as section 7.1. In addition, Qualtest assumes that step 12 of the test procedure is meant to return the test to 22°C and 40% RH, although this step does not specifically state that 40% RH must be maintained. For greater clarity, consider stating as "Following the 2 h stabilization period, return the temperature to 22°C at the 10°C/h rate *while maintaining 40% RH* and after a 2 h stabilization period, obtain the RID's response as described in steps 2, 3, and 4."

Section 7.4 – Dust and moisture protection: Same comments as section 7.1. *7.4.2 – Dust:* The standard references IEC 60529, which uses a chamber with a talcum powder medium. Many labs (including Qualtest) do not have a chamber that can use talcum powder as a medium. More common is red china clay or silica (MIL-STD-810). The medium for the chamber is not easily changeable due to cross contamination. *7.4.3 – Moisture:* It is unclear which specific spray test in IEC 60529 is required by N42.34-D6. **NOTE: Qualtest does not currently possess each specific spray nozzle identified in IEC 60529.**

Section 8.1 – Radio frequency (RF): The last sentence of 8.1.2d is confusing, given that earlier in the step the procedure states that the COV "shall be less than or equal to 12%." What to do if the COV is greater than 12% is not defined. It seems that if a ≤12% COV is the requirement, a statement about COV greater than 12% being acceptable is incorrect. The referenced standard (IEC 61000-4-3) lists the frequency range up to 6000 MHz rather than 2500 MHz as shown in section 8.1. Consider making the frequency range 80 MHz – 6000 MHz rather than 80 MHz – 2500 MHz. Also, test levels are based on some kind of analysis of the environment that the device is going into. The 3 V/m intensity requirement above 1000 MHz means there could be threats in the environment that are radiating at a level higher than that, but by only testing to 3 V/m, there will be no way of knowing if the device is immune to those threats or not, because of under-testing. Consider making the field intensity requirement 10 V/m over the entire frequency range tested.

Section 8.2 – Radiated emissions: The basis for the 50 kHz bandwidth is unclear – this is a non-standard bandwidth that may not be available on all analyzers/receivers used to perform emissions testing. Given the frequency range specified, a 100/120 kHz bandwidth selection would be better, with 120 kHz preferred. This puts the specified bandwidths in-line with those used in typical commercial emissions standards (FCC Part 15 and the various CISPR specifications). Also, the detection method to use for the scan (peak or quasi-peak detection) is unclear – most standards use peak detection, at least as an initial scanning method. Finally, for proper radiated emissions evaluation, a device should be tested in a chamber where the distance from antenna to the device is equal both horizontally and vertically. A requirement of 3 m gets into large, very expensive chambers. Many labs/chambers (including Qualtest) are designed for performing radiated emissions testing at 1 m.

Section 9 – Mechanical performance requirements: This section states that these requirements and test methods were derived from the "handheld" portions of IEC 62706, which defines environments that radiation protection instrumentation may be exposed to. While collaborating with Qualtest, Inc., several questions arose as to the purpose and validity of some of the mechanical performance tests of a RID. For instance, consider requirements to make each test reproducible – address how a RID should be fixed/clamped during vibration testing (section 9.1) and how toppling and secondary impacts should be prevented during drop testing (section 9.4). Also consider conducting the vibration tests of a RID in its case (Pelican case) since the most likely vibration that a RID would be subjected to would be in transport.

Section 9.1 – Vibration: The tolerance reference to use for this test (IEC 60721-3-7, MIL-STD-810, and IEC 60068-2-64 are all are listed within this section) is unclear. No axis definition is shown for the test item and no fixtures (clamps, straps, clamping bars, etc.) for the RID are mentioned. Consider establishing a dedicated vibration/shock fixture for an instrument for reproducible tests, acknowledging that test item mounting is a potential variable that can be controlled.

Section 9.2 – Mechanical shock: Same comment as section 9.1 for axis definition and fixture omissions. Shock axis definition should also include the positive (+) and negative (-) direction definition for unidirectional shock pulses. The reasoning behind subjecting the RID to 10 shocks is unclear since only three shocks in each direction of each axis (18 total shocks) are applied for non-repetitive shocks testing (as defined by IEC standards). Consider subjecting the RID to three shocks in each direction of each axis (18 total shocks).

Section 9.3 – Impact (microphonics): This test can only be performed by using the specialized equipment called out in this procedure (i.e. spring hammer) that is designed, fabricated, validated and calibrated to deliver the specified 0.2 joules to the Unit Under Test (UUT). **NOTE: Qualtest, Inc. does not currently possess this equipment and did not evaluate this procedure.**

Section 9.4 – Drop: The test method states "The drop shall be controlled to ensure that the RID lands on its bottom surface and does not topple following the drop." It is assumed that the purpose of the "non-topple" requirement is to prevent secondary impact pulses to the test item through other surfaces than the bottom. Consider establishing guidelines for preventing toppling after the RID is dropped for test reproducibility purposes.

4.0 Conclusions

Validation of ANSI N42.34-D6 for DNDO was completed by SRNL in collaboration with Qualtest, Inc. utilizing the FLIR identiFINDER 2. The variant of identiFINDER 2 used did not have neutron detection capabilities. SRNL and Qualtest, Inc. personnel were able to understand and follow each section of N42.34-D6, but identified specific candidate areas for improvement efforts, such as the following:

- Recommend for section 6.2 that the test duration and number of alarms acceptable be made consistent within the section – 2 alarms over a period of 5 hours.
- For better RID response and consistency, recommend that a test requirement of 50 μR/h above background versus 10 μR/h be implemented for section 6.3.
- Recommend for section 6.10 that "Unknown" or "Background" should be possible results for a RID in low-background environments.
- Recommend stating testing tolerances for environmental performance evaluation (section 7) and document the references for those tolerances.
- Recommend in section 7.4.2 that alternative dusting mediums (i.e., red china clay, silica) that are more commonly utilized than talcum powder be acceptable for testing.
- Define an axis of orientation and direction for a UUT in sections 9.1 (Vibration) and 9.2 (Mechanical shock), respectively.
- For section 9.4 (Drop), clarify how the test can be controlled to ensure the RID does not topple following a drop.
- Recommend throughout N42.34 that any information from other standards necessary for conducting the tests within N42.34 should be posted in N42.34 for simplicity and to prevent the user from having to peruse so many other documents (have an "all-in-one" standard).

This validation of the ANSI N42.34-D6 standard proves it has many positive traits for testing hand-held instruments (RIDs), but recommendations and requests for clarity should be considered prior to final ballot of the standard.

5.0 References

ANSI N42.34-D6, American National Standard Performance Criteria for Hand-Held Instruments for the Detection and Identification of Radionuclides.

FLIR identiFINDER 2 User Manual, July 2012.

SRNL datasheets.

Appendix A. Example photos during the SRNL validation of N42.34-D6

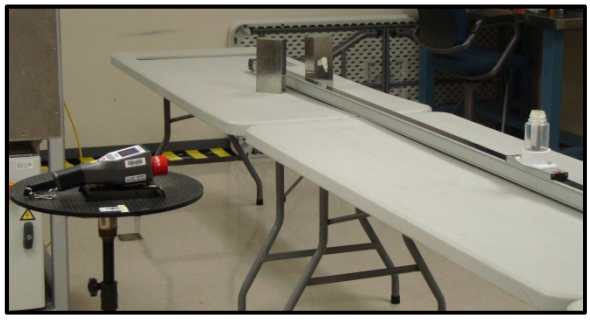

Figure 3. Setup of a test involving a moving source (speed of 0.5 m/s) – Section 6.3

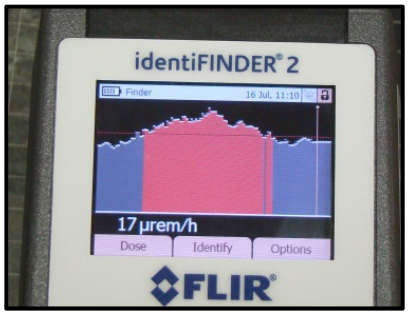

Figure 4. RID response to a passing source (^{137}Cs – test point distance 1.0 m; speed 0.5 m/s) – Section 6.3

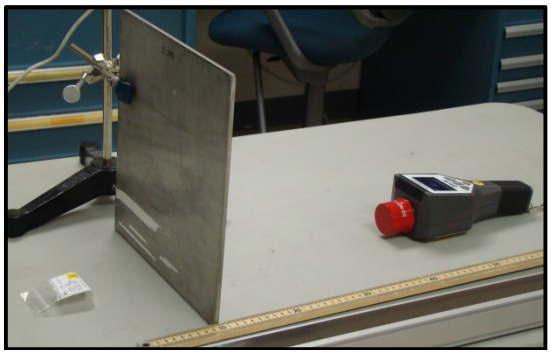

Figure 5. Setup for ID tests with shielding (5 mm steel plate) – Section 6.8

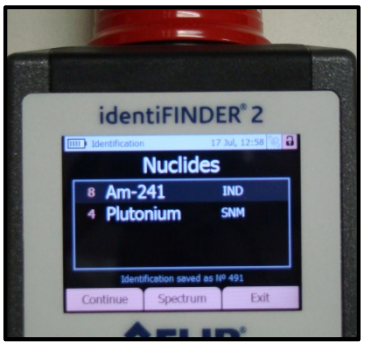

Figure 6. Example of an ID result display – Section 6.9

Figure 7. Setup for tests involving NORM (^{226}Ra and ^{232}Th sources surrounded by 9 cm of PMMA and co-located with ^{40}K (bags of water softener) – Section 6.9

Figure 8. RID inside a thermal chamber – Sections 7.1, 7.2, 7.3, and 7.5

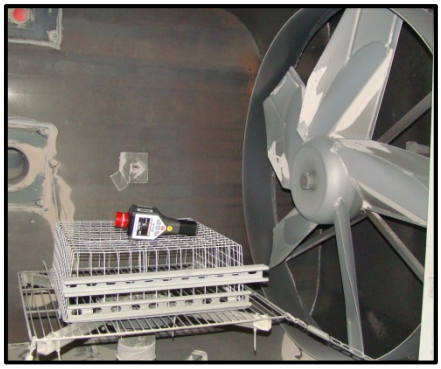

Figure 9. RID inside a dusting chamber – Section 7.4

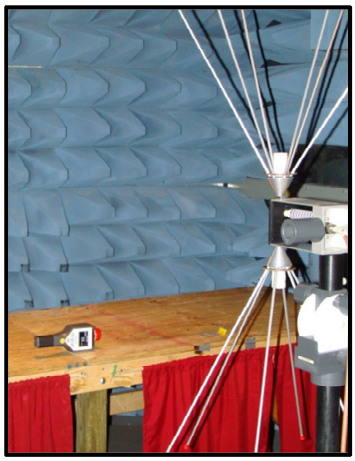

Figure 10. Setup for radiated emissions tests; biconical antenna in vertical plane – Section 8.2

Figure 11. Setup for magnetic field tests – Section 8.3

Figure 12. Walk-through of electrostatic discharge (ESD) tests – Section 8.4

NOTES: NORM = Naturally Occurring Radioactive Material; PMMA = Polymethyl Methacrylate. Figures 3, 4, 5, 6, and 7 were taken at SRNL; Figures 8, 9, 10, 11, and 12 were taken at Qualtest, Inc. More pictures appear in the datasheets.