Testing facility for the qualification of measurement devices suitable for detecting nuclear and radioactive material

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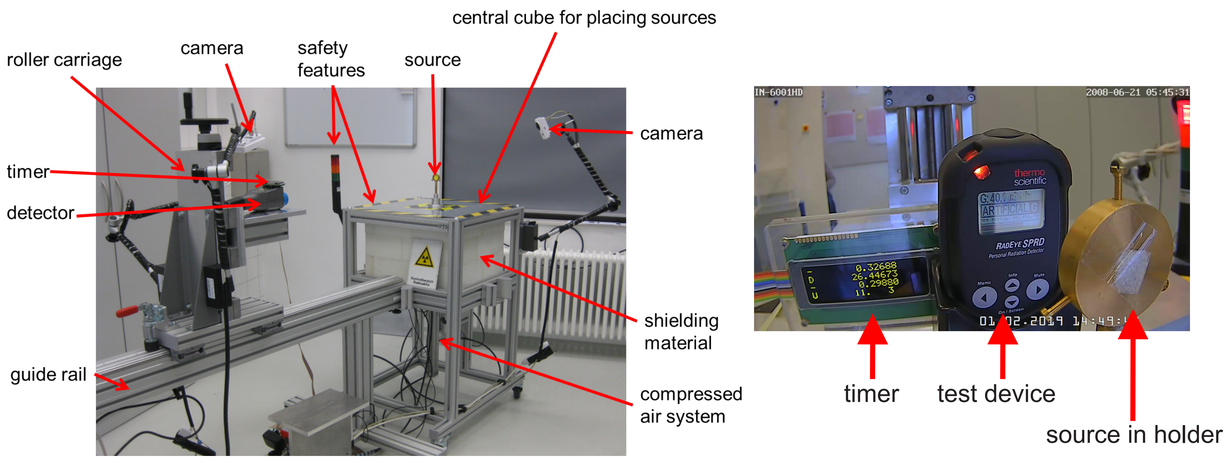
1. Motivation

In 2015 the European Commission launched the project ITRAP+10 Phase II (Illicit Trafficking Radiation Assessment Program) with the scope to test mobile and transportable systems for the detection of radioactive and nuclear (RN) material at the JRC in Ispra, to contribute to innovation and improvement of RN detection technologies as well as to the enhancement of international standards, and last but not least to enable European laboratories to build up their capacities to perform tests against standards and thereby to work as testing facilities for RN detection systems. As Fraunhofer INT has profound knowledge in the field of testing and assessing devices for the detection of RN materials we were chosen as one of the participating laboratories for building up testing and performance capacities and to take part in a Round Robin Test by performing tests with several types of selected RN detection devices (PRD, SRPM, RIID). In order to perform these tests, two test systems were designed and constructed: one static and one dynamic.

2. Test system for static measurements

2.1. Design and operation of the static test system

The static test system consists of a central cube housing the RN material required by the test procedure, a compressed air system for the source lift up mechanism (in about 0.35 s), shielding material, and additional some safety features. The RN material is positioned on a specific holder depending on the geometry of the source. Up to three guide rails can be attached to the cube. The measurement devices are placed using roller carriages for height adjustment and reproducible positioning.
The reaction of the device is observed and monitored by means of a video system for subsequent evaluation. The temporal behaviour is monitored using a timer (U: time in up position, D: time in down position, -: lift times).



Layout of the static test system: overview (left), monitoring of the device display with time (right).

2.2. Categories of evaluation

In the ITRAP+10 Phase II program this setting is needed for the evaluation of PRD (Personal Radiation Detectors) and RIIDs (Radiation Isotope Identifier Device). The test methods for the static test system include tests for:

- False identification rate
- Time to alarm for photons and neutrons
- Accuracy tests for photons
- Over range
- Gamma response of neutron detector and neutron response in the presence of gammas
- Single radionuclide identification
- Overload characteristics for identification

3. Test system for dynamic measurements

3.1. Design and operation of the dynamic test system

The dynamic test system was designed and constructed at Fraunhofer INT. Its main unit is a trolley carrying the RN material. The radioactive sources are mounted using the same sample holders as for the static system. The height can be easily adjusted. The trolley is remote-controlled and runs automatically along a monorail at a preselected velocity and acceleration. The dynamic system is transportable, e.g. on a trailer, for utilization at various locations.
The categories of evaluation regarding the dynamic test system are the same as for the static test system. Additionally, the dynamic sensitivity to photons and neutrons is investigated. The velocity range of the trolley goes from 0.02 m/s to 2.2 m/s and the available length of monorail is 44 m.

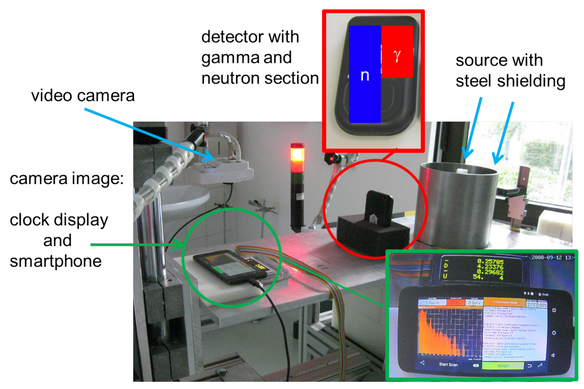
Trolley running on wheels along a monorail with source holder design on vertical rods (enlarged detail).

alternative source

4. Exemplary operation procedures and results

4.1. Static tests with a hand-held detection system (time-to-alarm)

One example of a measurement device that was tested with the static test system is the D3S from Kromek. It consists of a detection device, which is equipped with a CsI(Tl) gamma and a Li-based neutron detector, and a smartphone as data collection device and display. The device can be run as PRD as well as RIID.
Among other aspects it was tested concerning the time-to-alarm. ITRAP+10 phase II test procedures define limits of 2 s for PRDs (Personal Radiation Devices) and 3 s for RIIDs until alarming after being exposed to the radioactive source. The time to alarm shall be estimated over the whole energy region, therefore tests with ^{241}Am, ^{137}Cs, and ^{60}Co have to be performed with a dose rate of 0.5 µSv/h above background. 30 trials are required per measurement setup and the demands concerning the time-to-alarm must be fulfilled in every trial to pass the test.



Experimental setup for tests regarding the time-to-alarm.

Successful trials concerning PRD requirements (< 2 s):

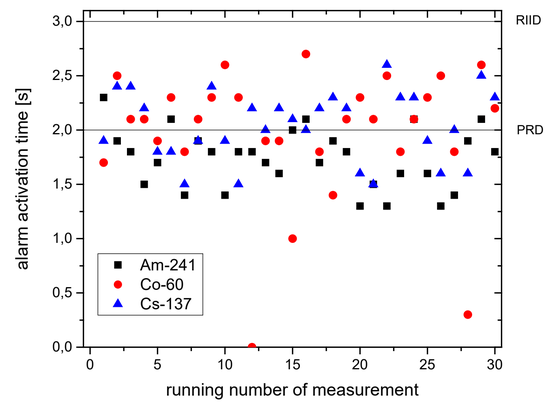
^{241}Am: 24/30; ^{60}Co: 12/30; ^{137}Cs: 12/30

-> test failed ✗

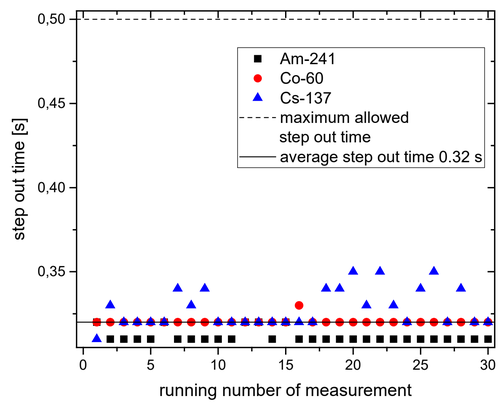
Successful trials concerning RIID requirements (< 3 s):

30/30 for all radioactive sources

-> test passed ✓



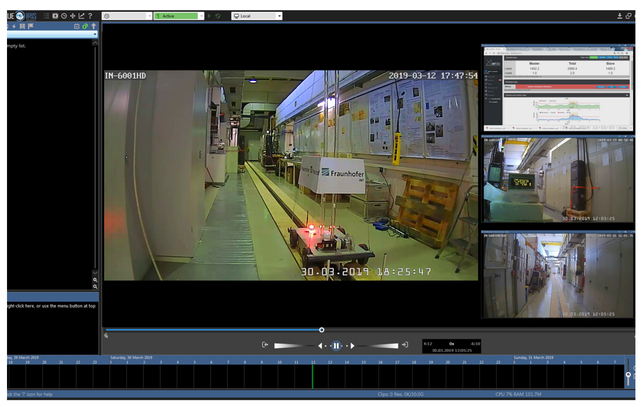
Time-to-alarm times, limits for PRDs and RIIDs are marked.



Step out times, all meet the criterion of < 0.5 seconds.

4.2. Video surveillance of the dynamic test system with the Blue Iris software

The video data of both the static and the dynamic test system are processed and controlled by means of the Blue Iris software. It is possible to review previously stored video data while recording. Several camera feeds can be viewed and stored simultaneously.



Desktop image of the Blue Iris software with several camera images of the dynamic test system with a pedestrian portal monitor as well as the screen of the tested measurement system.

5. Conclusions

- ► Fraunhofer INT has developed a static and a dynamic test system for the qualification of RN detectors of different device classes
- ► Detection systems can be qualified according to various standards
- ► Comparison of the quality of different detection systems is possible
- ► Both test system are mobile and can therefore be transported to different locations

6. Acknowledgement

Design and construction of the static and dynamic test system were part of the project ITRAP+10 Phase 2, co-funded by the Internal Security Fund of the European Union under the agreement number HOME/2015/ISFP/AG/CBRN/4000008453.

7. References

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M. Risse, T. Köble, et.al.: “Qualification setup for systems for measuring nuclear and radioactive material”, INMM annual meeting, Baltimore, MD, USA, 2018