HRP Job Aid: Rad Detection Equipment

DESCRIPTION	ECCN
Detection equipment, radiation	**1A004.c, 1A995.a, 1A999.a**
Electromagnetic radiation sensors, optical fiber	**6A002.d.3.a**
Radiation detection, monitoring and measurement equipment	**1A999.a**
Radiation hardened detectors	**6A002, 6A102**
Radiation hardened sensors, optical fibers	**6A002.d.3**
Radiation detectors and monitors "specially designed" for detecting or measuring special nuclear material (SNM)	**2A291.a**
Helium-3, mixtures containing helium-3, and products or devices containing any of the foregoing	**1C232**
Lithium enriched in the ^{6}Li isotope, and products or devices containing enriched lithium	**1C233**
Parts and Accessories	**EAR99**

EXPORT CONTROLS—QUICK OVERVIEW

Most radiation detection equipment	**ECCN 1A999**
Handheld first responder detectors	typically **ECCN 1A004** (NS controls)
Personal radiation monitoring dosimeters	**ECCN 1A995.a**
General purpose radiation detectors: Geiger counters, survey meters	**ECCN 1A999**
Boron trifluoride (BF3) detectors and B10 lined detectors	typically **ECCN 1A999**
Equipment specifically designed for detection of SNM	**ECCN 2A291** (NP controls)
Certain models of 3He tubes (if ≥1 g 3He)	**ECCN 1C232**
Modern radiation detectors are increasingly using enriched 6Li	**ECCN 1C233**

Note: This training aid focuses on equipment for the detection and identification of radioactive materials as controlled under DOC 15 CFR 774 regulations.

Equipment "especially designed or prepared" (EDP) for sampling, monitoring, or analyzing radioactive materials (e.g., uranium, plutonium) during the processing, use, or production of Special Nuclear Material (SNM) in a nuclear fuel cycle facility would be considered Trigger List and controlled under the US Nuclear Regulatory Commission's 10 CFR 110 regulations.

Examples

- In-line assay monitor equipment for UF6 enrichment
- Mass spectrometers with online sampling and isotopic analysis capability

Major Manufacturers

- Ludlum Measurements Inc. (Sweetwater, TX)
- ORTEC/AMETEK Process Instruments (Pittsburgh, PA)
- Thermo Fisher Scientific (Waltham, MA)
- Nucsafe (Oak Ridge, TN; Corbin, KY)
- Polimaster Ltd. (Sterling, VA)
- Mirion Technologies Inc. (acquired Canberra Industries Inc.; San Ramon, CA)
- Smith Detection Inc. (Danbury, CT)
- Rapiscan Systems (Torrance, CA)
- LND Inc. (Oceanside, NY)—A primary supplier of 3He and BF3 neutron detectors for radiation portal monitors (RPMs) at borders and shipping ports
- Radiation Detection Technologies Inc. (Manhattan, KS)
- JRT Associates (Elmsford, NY)
- Centronic Limited (Croydon, United Kingdom)
- Scintacor (lithium-based detectors; Cambridge, United Kingdom)
- Silverside Detectors Inc. (Waltham, MA)—Lithium-based detectors for RPMs

Aliases

Look for any of the following

- Personal radiation monitoring dosimeters
- Personal radiation detectors (PRD)
- Geiger counters or Geiger–Müeller (G-M) tubes
- End- and side-window X-ray proportional counters
- Position sensitive detectors
- BF3 and 3He neutron proportional detectors/tubes
- Ionization chambers
- Fission counters
- Neutron beam monitors
- Flow counters
- Polymer window proportional counters
- Multiwire proportional counter (MWPC)
- Optical fiber sensors (OFS)
- Radiation portal monitors (RPM)
- Nuclear event detector (NED)
- Handheld or portable radioisotope identification devices (HHRIIDs or RIIDs)

Radiation Detection Equipment Applications

- Health physics
- Analytical instrumentation
- Environmental and air quality monitoring
- Personnel monitoring
- Power plant applications
- Nuclear material processing
- Industrial gauging
- Medical instrumentation
- High-energy physics research
- X-ray spectroscopy
- Nondestructive testing
- Homeland security
- Space exploration

Detection Systems and Components

ECCN 1A004.c

ITEMS CONTROLLED

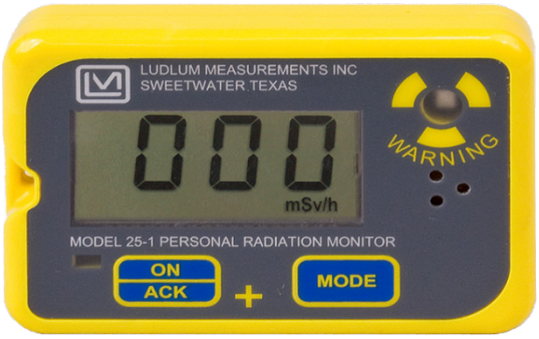
- Detection systems, specially designed or modified for detection or identification of any of the following, and specially designed components" therefore:
- c.2. Radioactive materials

NOTES

- ECCN 1A004.c does not control personal radiation monitoring dosimeters (see ECCN 1A995.a).
- Radioactive materials are those selected or modified to increase their effectiveness in producing casualties in humans or animals, degrading equipment or damaging crops or the environment.

AccuRad personal radiation detector by Mirion Technologies

- Designed for law enforcement, border security, fire rescue, and other emergency responders to detect and interdict nuclear and radioactive materials
- Gamma detection
- 4.25 in. × 2.40 in. × 1.42 in.
- **ECCN 1A004.c**



Ludlum Model 25 personal radiation monitor

- Gamma detection: Displays dose rate, accumulated dose, and time remaining to the dose limit
- Plastic housing; lithium coin cell batteries; backlit LCD display

Personal Radiation Monitoring Dosimeters ECCN 1A995.a

ITEMS CONTROLLED

- Protective and detection equipment not specially designed for military use and not controlled by ECCN 1A004 or ECCN 2B351, as follows, and parts and components not specially designed for military use and not controlled by ECCN 1A004 or ECCN 2B351
  - – Personal radiation monitoring dosimeters

Pencil dosimeter, Model AT-725, by Ludlum Measurements Inc.

- Sensitive to gamma rays and X-rays
- 0–5 R
- Applications: Personal and environmental monitoring; hospital applications including fluoroscopy, portable radiography, and angiography
- **ECCN 1A995.a**

Personal dosimeter by ATOMTEX (Model AT2503B)

- Simultaneous measurement of gamma radiation personal dose equivalent and personal dose equivalent rate
- Pocket-sized
- Dosimeter-to-PC communication via reader

Detection, Monitoring and Measurement Equipment

ECCN 1A999.a

ITEMS CONTROLLED

- Radiation detection, monitoring and measurement equipment, n.e.s.

NOTES

- A license is required for items controlled by this entry to North Korea for antiterrorism reasons.

Cylindrical BF3 neutron detectors

- Typically consist of a cylindrical aluminum tube with a BF3 fill gas
- **ECCN 1A999**

Centronic boron trifluoride (BF3) neutron proportional counter (top); boron-lined proportional counter (bottom)

- Applications: Neutron diffraction, neutron spectroscopy, mixed waste monitoring, soil moisture detection, monitoring of nuclear reactors

ORTEC RADEAGLE state-of-the-art handheld radioisotope identifier

- Used routinely in the front line of operations to interdict the illicit trafficking of nuclear materials worldwide
- Organizations: DHS, DOD, NNSA, emergency response teams, military, police departments, nuclear safeguards organizations, nuclear researchers

Detection, Monitoring and Measurement Equipment

ECCN 1A999.a

ORTEC "Detective X" ultrahigh resolution HPGe radioisotope identifier

Ludlum Model 44-9 GM (Geiger-Müeller) radiation detector

- Monitoring of alpha, beta, and gamma radiation on personnel, objects, and surfaces
- Slip-resistant grip, beige powder-coated metal housing, stainless steel screen

Ludlum Model 43-1-1 alpha-beta detector

- Alpha-beta survey meter
- Construction: Aluminum housing with beige powder coat; series "C" connector
- Size: 9.8 in. L × 4.8 in. D
- Weight: 2 lb

Detection, Monitoring and Measurement Equipment

ECCN 1A999.a

Ludlum Model 43-93 alpha-beta scintillation detector

- Simultaneous alpha and beta survey
- Construction: Aluminum with beige powder coat; series "C" connector; square mesh protective screen
- Size: 12.3 in. L × 3.8 in. W × 2.5 in. H
- Weight: 1 lb

RAPISCAN PRM470 handheld radiation monitor

- Gamma and neutron sensitivity
- Applications: Locating radioactive sources, monitoring contaminated areas, performing background monitoring
- Gamma detector material: Organic plastic scintillator
- Neutron detector material: Helium-3 tube
- Dimensions: 7.85 in. H × 4.75 in. W × 3.5 in. D
- Weight: 2.4 lb with batteries

Ludlum Model 42-38 WENDI-2 wide energy neutron detector

- Detection of thermal and fast neutrons; used with area monitors and portable survey meters
- Detector: 2 atm 3He tube
- Moderator: Polyethylene cylinder
- Size: 9 in. D × 13 in. L
- Weight: 30 lb

Detection, Monitoring and Measurement Equipment

ECCN 1A999.a

CHECK SOURCES

- Frequently attached to radiation detection equipment controlled under ECCN 1A999
- Thin (0.010 in. thick) in sizes up to 1 in. diameter
- Look for "exempt quantity" **EAR99**

Standard plastic disk check source (137Cs) with accompanying stick-on source holder.

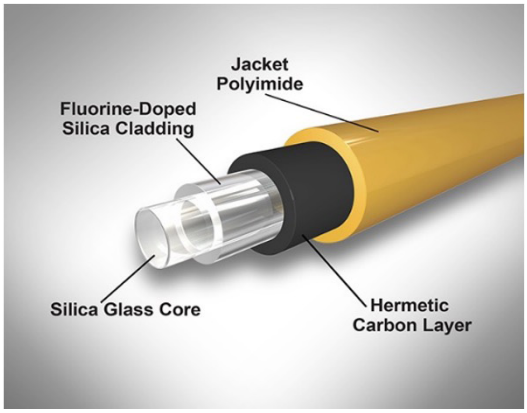
Optical Sensing Fibers—Radiation Sensitive ECCN 6A002.d.3

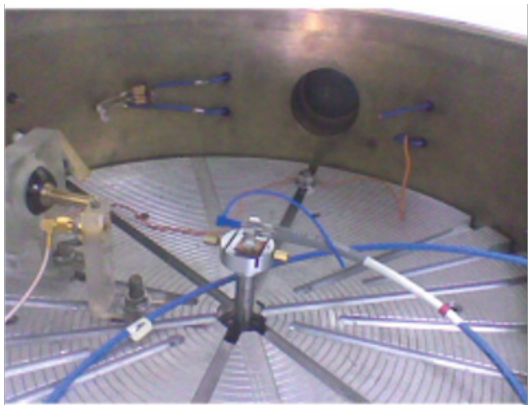
ITEMS CONTROLLED

- Optical sensing fibers specially fabricated either compositionally or structurally, or modified by coating, to be acoustically, thermally, inertially, electromagnetically, or nuclear radiation sensitive.

NOTES

- ECCN 6A002.d. does not apply to encapsulated optical sensing fibers specially designed for bore hole–sensing applications.



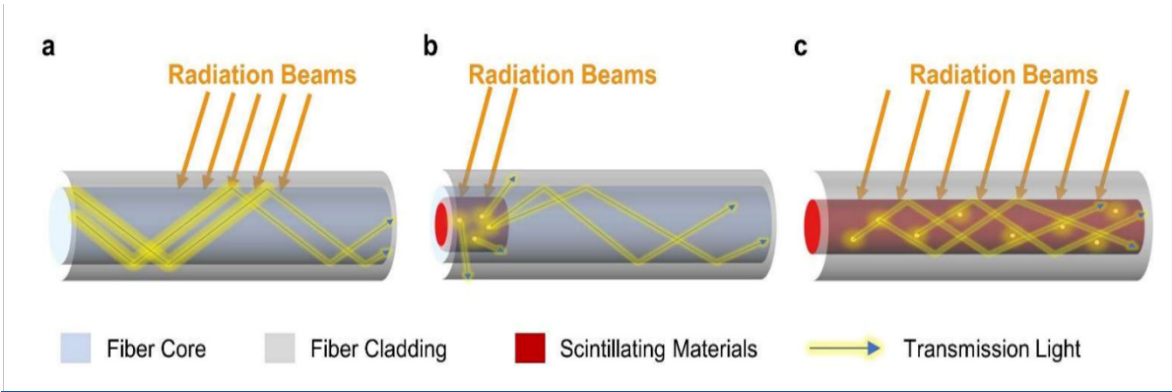


Optical fiber sensors used in ionizing radiation environments.

COMMENTS AND KEY FEATURES

- Increasingly used as radiation sensors benefiting from advancements in optical fiber manufacturing and materials engineering
- Small in size, lightweight, long in the sensing distance, moisture-proof, corrosion-resistant, non-conductive, and antielectromagnetic interference
- Flexible and bendable; ideal for inserting into narrow, curved, and complex environments
- Composite structures with multimaterials, including semiconductors, metals, doped silica glasses, oxide glasses, and functional polymers
- Extrinsic sensor: Optical fiber acts as a light guide of the radiation-generated optical signal
- Intrinsic sensor: Fiber material constitutes the detecting medium, where light is produced under radiation exposure
- Resistant to harsh environments (high temperature, high pressure, gamma and neutron radiation)
- Applications: Nuclear energy, high-energy physics, aerospace, military, and medical treatment

Optical Sensing Fibers—Radiation Sensitive ECCN 6A002.d.3



Sensing principles of extrinsic and intrinsic optical fiber radiation sensors

(a) Radiation-induced attenuation (RIA) based optical fiber radiation sensor

(b) Radiation-induced luminescence (RIL) based optical fiber radiation sensor with extrinsic scintillator

(c) Radiation-induced luminescence based optical fiber radiation sensor with scintillating fiber core

Look for any reference to these sensing acronyms on paperwork:

- Radiation-induced attenuation (RIA)
- Radiation-induced luminescence (RIL)
- Fiber grating–wavelength shifting (RI-GWS)

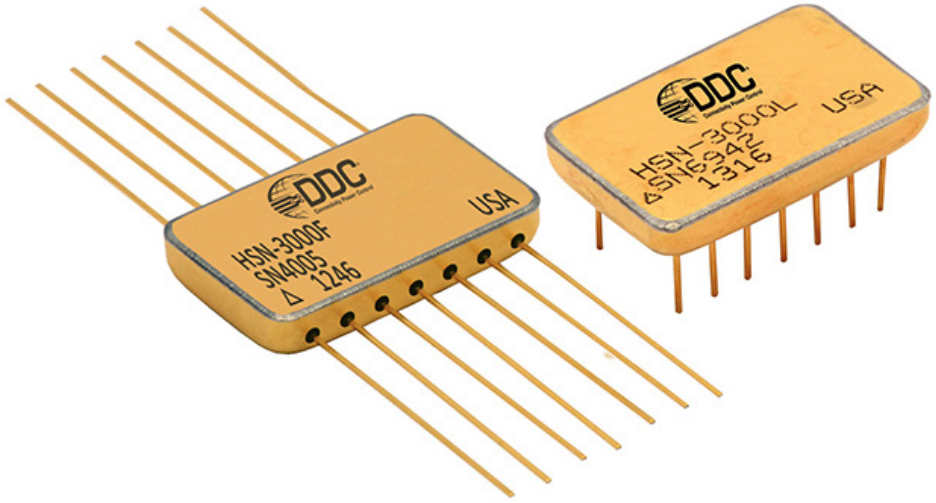
Radiation Hardened Detectors—Nuclear Effects ECCN 6A102

ITEMS CONTROLLED

- Radiation hardened detectors, other than those controlled by ECCN 6A002, specially designed or modified for protecting against nuclear effects (e.g., electromagnetic pulse (EMP), X-rays, combined blast and thermal effects) and usable for missiles designed or rated to withstand radiation levels that meet or exceed a total irradiation dose of 5 × 105 rads (silicon).

DEFINITIONS

- **Detector**—Under ECCN 6A102, a detector is defined as a mechanical, electrical, optical, or chemical device that automatically identifies and records or registers a stimulus such as an environmental change in pressure or temperature, an electrical or electromagnetic signal, or radiation from a radioactive material.



HSN-3000 Nuclear Event Detector

- Teledyne Microelectronic Technologies
- Dimensions (typical): 0.8 in. L × 0.5 in. H × 0.15 in. D
- 14 pins
- Radiation hardness characteristics:
  - Dose rate (operate-through): 1 × 1012 rad(Si)/s
  - Total dose: 1 × 106 rad(Si)

Specially Designed for Detecting or Measuring SNM

ECCN 2A291.e

ITEMS CONTROLLED

- Radiation detectors and monitors specially designed for detecting or measuring SNM (defined in 10 CFR Part 110 as Pu, 233U, or U enriched above 0.711% by weight in 235U) or for nuclear reactors.

NOTES

- ECCN 2A291.e does not control neutron flux detectors and monitors. These are subject to the export licensing authority of the U.S. Nuclear Regulatory Commission, pursuant to 10 CFR Part 110.
- ECCN 2A291.e does not control general purpose radiation detection equipment, such as Geiger counters and dosimeters. These items are controlled by ECCN 1A999.

SPECIAL NOTE

- R&D in nuclear arms control verification and monitoring technologies
- HEU transparency; references to Blend Down Monitoring System (BDMS)
  - Nuclear Warhead Safety and Security (WSSX)
  - Nuclear Material Identification System (NMIS)
- Activities related to material control and accountability
- Activities supporting the Stockpile Stewardship Program

Blend Down Monitoring System Installation at Paducah Gaseous Diffusion Plant

- Measurement of fissile (235U) mass flow rate (flow detectors) and enrichment of UF6 (enrichment detector)
- Flow and enrichment control cabinets with computers and data recording

Specially Designed for Detecting or Measuring SNM

ECCN 2A291.e

Enrichment detector (UF6 process pipe in background)

- Cobalt-57 source; thallium-activated sodium iodide NaI(Tl) detector

RAPISCAN Systems Guardian VM 1000 Drive-Through RPM

- Detects illicit radionuclides including SNM concealed in conveyances ranging from passenger vehicles to tractor trailer trucks and trains
- Exceptional gamma and neutron sensitivity
- Number of panels: Four (two per pillar, stacked)
- Gamma detection material: Polyvinyl toluene (PVT) plastic scintillator
- Neutron detector material: LiZnS (Ag)
- External panel dimensions: 80 in. H × 26 in. W × 7.3 in. D
- Weight: 710 lb (per panel)

Products or Devices Containing Helium-3 (^{3}He)

ECCN 1C232

ITEMS CONTROLLED

- Helium-3, mixtures containing helium-3, and products or devices containing any of the foregoing.
- **Does not control a product or device containing <1 g of ^{3}He**

NOTES

- Radiation detection systems using 3He tubes will often comprise more than one tube.
- The gram limit is per tube, not a total of all tubes. The tube is considered the "device."
- The control applies to what the tube can contain not what it does contain.
- Determining the amount of 3He in a product or device will typically require contacting the manufacturer or having detailed technical specifications (e.g., tube internal pressure) available for a subject matter expert.
- The Office of Nuclear Physics Isotope Program within the U.S. Department of Energy's Office of Science is the current broker for distribution of 3He. Russia is the only other supplier of 3He.
- The massive increase in demand of 3He (e.g., deployment of RPMs around the world) has diminished the stockpile and created a significant shortage of the material.
  - Current demand for 3He is approximately 65 m3 per year, but the supply is only about 20 m3 per year.
- **Applications**: Nuclear material assay, decommissioning, waste management, fuel fabrication systems, nuclear safeguards (e.g., International Atomic Energy Agency) for quantification of SNM at nuclear facilities, monitoring moisture content in soil and concrete, RPMs at seaports and border crossings around the world.

Note: A typical 3He detector consists of a cylindrical aluminum tube filled with helium at a pressure of several atmospheres.

LND Inc. Model 25169 3He neutron detector proportional counter tube. Controlled under ECCN 1C232.

Centronic limited 3He neutron proportional counter.

Products or Devices Containing Enriched Lithium

ITEMS CONTROLLED

- Lithium enriched in the 6Li isotope to greater than its natural isotopic abundance, and products or devices containing enriched lithium, as follows: elemental lithium, alloys, compounds, mixtures containing lithium, manufactures thereof, and waste or scrap of any of the foregoing.
- **This entry does not control thermoluminescent dosimeters (TLDs).** The most popular TLD material for personnel dosimetry is lithium fluoride (LiF).

Multielement TLD card dosimeters containing the radiation-sensitive material lithium fluoride (not controlled).

NOTES

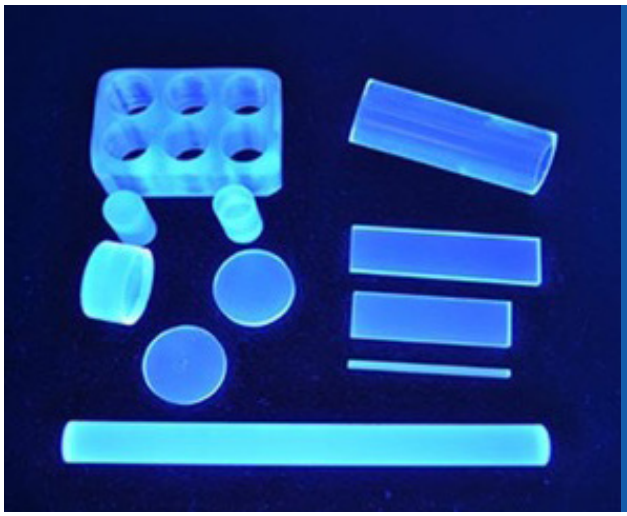
- The natural isotopic abundance of 6Li is approximately 6.5 wt.% (7.5 at.%).

KEY INFORMATION ABOUT ^{6}LI AND LITHIUM DETECTORS

- The detector of choice for several decades has been the 3He gas–filled proportional counter.
- However, in the past two decades, the stockpile of 3He has been greatly depleted with no viable means for increasing production to meet demand.
- Therefore, many alternative technologies have attracted interest, including 6LiF-based scintillators, lithium-loaded plastic scintillators, and 6LiF-filled microstructured semiconductor detectors.
- Lithium-based neutron detectors are more cost-effective than 3He-based neutron detectors. The lower cost of the detector is a direct result of recent advances in lithium foil manufacturing in the lithium battery industry.
- Lithium-6 is a metal that is highly reactive with neutrons.
- Lithium content and enrichment determine neutron sensitivity, which is higher for 6Li enriched glass, whereas 6Li depleted glass is almost insensitive to neutrons.
- Key advantages of 6Li glass over gas tubes are their sensitivity, fast timing, and dynamic range.

BE AWARE OF THE FOLLOWING

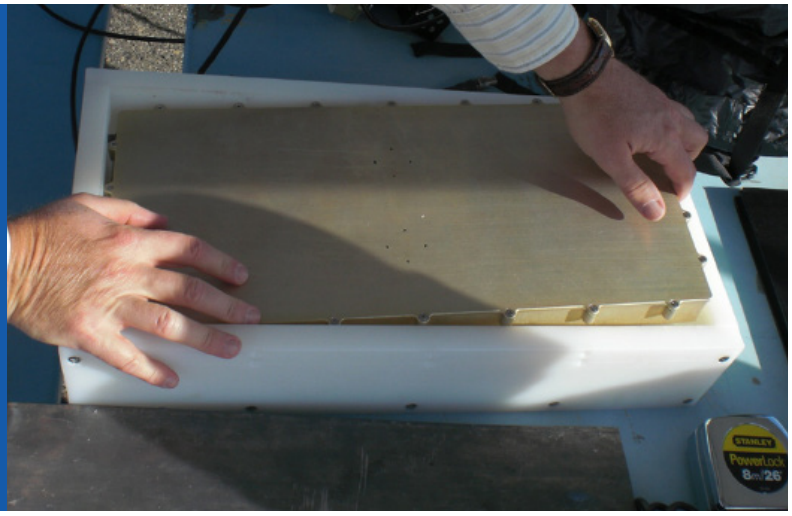
- **Guardian™ Glass**—Rapiscan Systems, AS&E (Billerica, MA)
- **SG101** (enriched 6Li doped glass scintillators)—Hangzhou Shalom Electro-Optics Technology Co. Ltd., China
- Detection equipment with an R&D history associated with
  - **Northwestern University/Argonne National Laboratory**
  - **Kansas State University**
- Detection equipment by **Silverside Detectors Inc**. (Waltham, MA)
- References to multiwire proportional counters

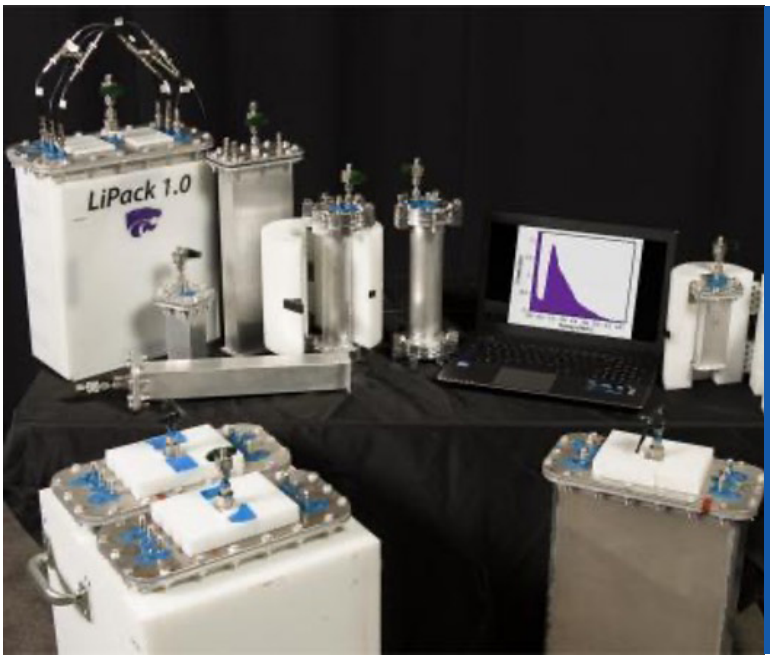


Guardian Glass for neutron detection

- Detection capabilities: Thermal neutron, neutron radiography, neutron, and/or gamma
- Detector material: Enriched ^{6}Li
- Detector base material: Glass
- Configurations: Rod, disks, plate, and tubes
- Typical flat dimensions: 10–200 mm
- Thickness: 1–50 mm
- Total lithium (wt.%): 2.4%–7.5% of enriched ^{6}Li (95%)

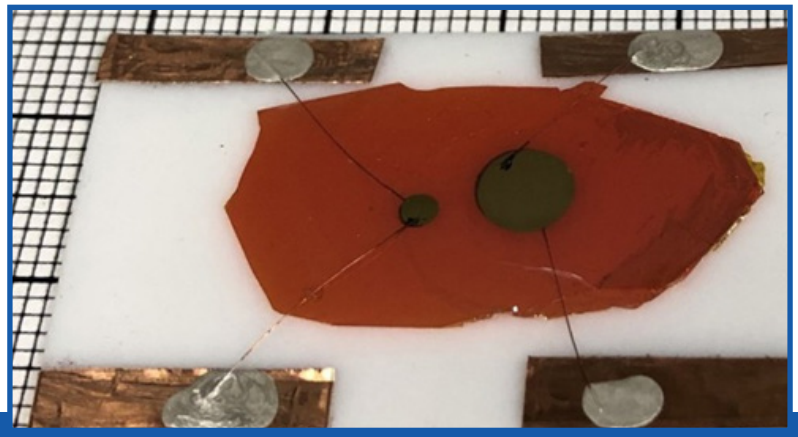
Nucsafe detector containing 6Li glass being placed into polyethylene moderator box.





Kansas State University–developed lithium-based neutron detectors

- Applications: Medical imaging, national security, scientific research, oil well logging, and automotive industry
- 2014 R&D 100 Award recipient



Prototype of pocket-sized neutron detector

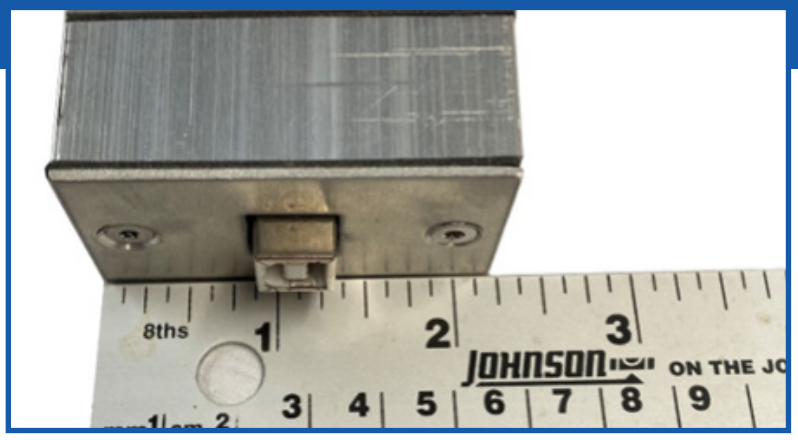
- New semiconductor material—lithium, indium, phosphorous and selenium ($LiInP_2Se_6$)—layered in structure and enriched to 95% with ^6Li
- Rapidly detects neutrons from even a very weak source
- Discriminates between neutrons and other types of nuclear signals, such as gamma rays, preventing false alarms
- Developed by Northwestern University and Argonne National Laboratory

Radiation Detection Technologies Inc.

- Spin-off of the Kansas State University Semiconductor Materials and Radiological Technologies (SMART) Laboratory
- Company focus: New products for replacement of traditional radiation-detection technologies due to the ^{3}He shortage

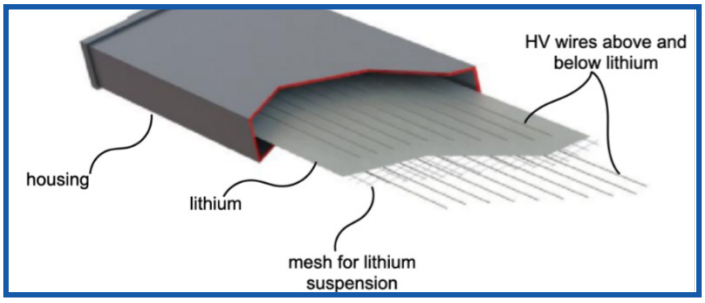
Radiation Detection Technologies Li-foil multiwire proportional counter neutron detector

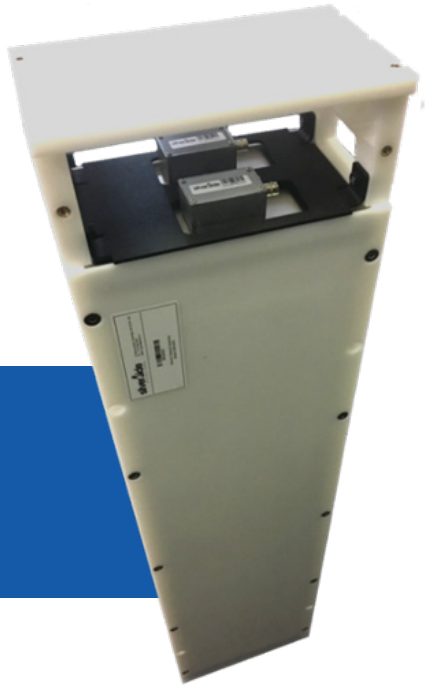
- Lithium-6 metal foils (95% enrichment) suspended between banks of anode wires



Silverside Detectors Inc. NDC-1000 neutron detector chamber

- Designed for RPMs
- Enriched 6Li metal suspended within a hermetically sealed chamber
- 2 in. × 8 in. rectangular tube × 36 in. L





Silverside Detectors Inc. SUB-5000 modular subsystem

- Composed of detector chambers and moderator
- Custom fit to any RPM system

Parts and Accessories

ECCN EAR99

- Low-technology parts and accessories associated with radiation detection equipment are classified as EAR999 and do not require an export license in most cases. Examples include cables, connectors, and adapters.
- Due diligence still needs to be performed to ensure the item is not going to an embargoed or sanctioned country, a prohibited end user, or a prohibited end use.

Tee connectors and adapters

Detector collimators (99% lead)

Cables with "C" type connectors

Signal splitter

Instrument handle

Tee connectors and adapters.

Detector clips

Transport and storage cases