CEMRC
DOE LIE DOWN AND BE COUNTED (LDBC) BY ANSI COMPLIANT IN-VIVO LUNG AND WHOLE BODY COUNTING SYSTEM - BASICS

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CEMRC
DOE LIE DOWN AND BE COUNTED (LDBC) PROJECT BY IN-VIVO LUNG AND WHOLE BODY COUNTING SYSTEM - BASICS

Carlsbad Environmental Monitoring & Research Center
College of Engineering
New Mexico State University
Carlsbad, New Mexico, USA

AMERICAN NUCLEAR SOCIETY MEETING
CARLSBAD, NM, USA
FEBRUARY 27, 2020
OVERVIEW

• Purpose of the LDBC Program
• Salient features of CEMRC In-vivo Lung and Whole Body Counting System and Compliance with American National Standards Institute, Inc.
• ANSI/HPS N13.30 2011 Direct Radiobioassay Performance Criteria
• Lie Down and Be Counted (LDBC) Program
Purpose:

• CEMRC has been performing Lung and whole body *in-vivo* radiobioassay services since 1997.

• Free for public volunteers living within a 100-mile radius of the WIPP site.

• The ongoing program is provided as an outreach service to the public to bring awareness about environmental radioactivity and radiation.

• The data provided will be used to evaluate and reduce the uncertainties associated with *in-vivo* radiobioassay measurement.
CEMRC INTERNAL DOSIMETRY DEPARTMENT

• **Conducts analyses and consultation** for the study of internal radiation exposure.

• **Provides support to Waste Isolation Pilot Plant (WIPP)** by conducting *in vivo* radio-bioassays for radiation workers on a routine basis.

• **Provides services** to other entities that employ the use of radioactive materials.

• **Provides an outreach service** to the public to provide assessments of potential exposure to radioactive contaminants of concern.

• **Supports education** about naturally occurring radioactivity and CEMRC’s environmental studies.
What is ANSI?

• The American National Standards Institute
• A private non profit organization that promotes and facilitates voluntary consensus standards and promoting their integrity
• There are lots of committees that continually update standards every five years
• Certain professional committees take the lead in coordinating certain topics
• The N-13 committee (Radiation Protection) and in coordinated by the Health Physics Society (HPS)
ANSI/HPS N13.30 2011 PERFORMANCE CRITERIA FOR RADIOBIOASSAY OF PUBLIC VOLUNTEERS

Facility Criteria: The laboratory shall be adequately

- Equipped
- Shielded
- Provided with necessary services
- Appropriately located
- DOELAP Accredited
CEMRC LUNG AND WHOLE BODY COUNTING SYSTEM

- Consists of 2 types of High Purity Germanium (HPGe) detectors:
  - Broad energy (BEGe) Lung detectors
  - Coaxial (COAX) Whole body detectors
- Made by Canberra - Mirion Technologies
The Broad Energy (BEGe) lung detectors:
• Consists of four detectors arranged in groups of two on each side of the chest.
• The two groups are incorporated into a single 7-liter LN2 cryostat.
• Provides low-energy signals from 8 to 250 keV based on the sum of the four BEGe (#1 - 4) for the lung measurement.
• Provides high-energy signals from 100 to 2000 keV based on the sum of the four BEGe (#5-8), to enhance the high energy signals for the Whole body counting.
• Positioning mechanism provides for longitudinal, vertical, and lateral positioning angles, as well as lateral and longitudinal tilt adjustments.
COAXIAL GERMANIUM WHOLEBODY DETECTORS

The Coaxial (Coax) Whole body detectors

- Consists of four detectors arranged beneath the bed
- Each detector is independently coupled to 15-liter LN2 cryostat.
- Consists of the Whole body geometry and can detect high energy signals from 100-2000 keV
- This geometry was experimentally determined to maximize sensitivity.
ANSI/HPS N13.30 2011 PERFORMANCE CRITERIA FOR RADIOBIOASSAY OF PUBLIC VOLUNTEERS

Shielding:

- Chamber is 9X10X9 ft and constructed from 10 inch thick cast iron (Fe) obtained from pre-WW II iron found in Texas and Oklahoma
- Constructed from 32 sections that comprise the door, walls, and ceiling.
- The door weighs over six tons and is operated by a hydraulic tank that is maintained at 120 Psi
- Entire chamber weighs around 150 tons
- Includes a graded z-liner that’s comprised of layers of decreasing z material. (Lead, tin, and stainless steel)
ANSI/HPS N13.30 2011 PERFORMANCE CRITERIA FOR RADIOBIOASSAY OF PUBLIC VOLUNTEERS
Location:

- Should be located at an appropriate distance from areas where radioactive materials are stored, processed and transported.
- However, the radioactive sources used for internal dosimetry, housed at CEMRC are about 18 ft (550 cm) away from the detectors.
Equipment:

- The systems measurement response stability shall be established by means of a check source and a “tolerance chart.”
  
  a. Response should not vary by more than ± 5% from established mean
  
  b. Should be checked at the beginning, conclusion, and a min of every 8 hours of the operating period.
## COMPLIANCE WITH ANSI N13.30 2011
### DIRECT RADIOBIOASSAY PERFORMANCE CRITERIA

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Limits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Centroid</td>
<td>± 2 channels from the centroid</td>
</tr>
<tr>
<td>Area</td>
<td>± 5% of established QC Boundary</td>
</tr>
<tr>
<td><strong>CEMRC Administrative Controls</strong></td>
<td></td>
</tr>
<tr>
<td>FWHM Lung Detectors</td>
<td>0.3 keV – 1 keV</td>
</tr>
<tr>
<td>FWHM Whole Body Detectors</td>
<td>1 keV – 4 keV</td>
</tr>
</tbody>
</table>
FWHM TOLERANCE CHART WITH ADMINISTRATIVE BOUNDARIES

Chart shows an example of peak area of 59.5 keV gamma-ray energy peak, with upper and lower boundaries for one of the detectors, over the time period August to December.

FWHM 59.5 keV
Personnel Preparation:

- Prior to the initial direct radiobioassy, volunteers should be given an orientation briefing on procedures that are to be followed in order to promote a relaxed mood and confidence in the operator and system.
- Reorientation performed as necessary.
Services:

- Anticlaustrophobial features
  a. Fail safe door-opening device that can be operated by the subject being counted
  b. A two-way hands-free intercom
  c. Music provided by a streaming service
  d. Restful lighting
  e. Adequate ventilation shall be provided in measurement area
  f. Contamination free clothing available to personnel for in-vivo measurements
Quantification:

- Quantification shall be by calibration with known sources of the radionuclides incorporated in a phantom of the body (or body part of interest)
Decision Level (Lc):

- The amount of a count or measurement at or above which a decision is made that the analyte is definitely present.

- \( L_c (cs^{-1}) = \frac{2.33 \sqrt{C_{gross}}}{t} \)
Minimum Detectable Amount (MDA)

- This value represents the minimum amount of a radionuclide that, if present, would be detected 95% during routine operation

\[ MDA \ (Bq) = \frac{3.29 \sqrt{S_{B1}^2 + S_{B0}^2} + 3}{K \times t \times U} \]
### CEMRC LUNG & WHOLEBODY DETECTOR MDA EXAMPLE

<table>
<thead>
<tr>
<th>CWT (cm)</th>
<th>1.6</th>
<th>2.22</th>
<th>3.01</th>
<th>3.33</th>
<th>4.18</th>
<th>5.10</th>
<th>6.0</th>
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</thead>
<tbody>
<tr>
<td>Radionuclide</td>
<td>Energy (keV)</td>
<td>MDA (nCi)</td>
<td>MDA (nCi)</td>
<td>MDA (nCi)</td>
<td>MDA (nCi)</td>
<td>MDA (nCi)</td>
<td>MDA (nCi)</td>
</tr>
<tr>
<td>AM-241</td>
<td>59.50</td>
<td>0.18</td>
<td>0.23</td>
<td>0.30</td>
<td>0.34</td>
<td>0.46</td>
<td>0.65</td>
</tr>
<tr>
<td>Pu-238</td>
<td>17.10</td>
<td>18</td>
<td>41</td>
<td>120</td>
<td>185</td>
<td>586</td>
<td>2032</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Radionuclide</th>
<th>Energy (keV)</th>
<th>MDA (nCi)</th>
<th>1 Standard Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Co-60</td>
<td>1333</td>
<td>0.36</td>
<td>0.01</td>
</tr>
<tr>
<td>Cs-137</td>
<td>662</td>
<td>0.42</td>
<td>0.02</td>
</tr>
</tbody>
</table>

See Reference (1) for detailed information
Performance Testing

- Shall be tested at least once every 3 years for each radionuclide.
- Shall be evaluated by an on-site assessment team at least every 3 years.
- DOE Laboratory Accreditation Program (DOELAP) provides performance testing
<table>
<thead>
<tr>
<th></th>
<th>DOELAP accreditation effective date</th>
<th>DOELAP accreditation expiration date</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1/9/1999</td>
<td>11/19/2003</td>
</tr>
<tr>
<td>2</td>
<td>8/19/2003</td>
<td>8/1/2006</td>
</tr>
<tr>
<td>3</td>
<td>8/1/2006</td>
<td>8/1/2009</td>
</tr>
<tr>
<td>4</td>
<td>9/30/2009</td>
<td>November, 2013 (actual date not available)</td>
</tr>
<tr>
<td>5</td>
<td>1/6/2014</td>
<td>8/1/2016</td>
</tr>
<tr>
<td>6</td>
<td>12/16/2016</td>
<td>8/1/2019</td>
</tr>
<tr>
<td></td>
<td>(DOELAP notification)</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>1/1/2020</td>
<td>12/31/2022</td>
</tr>
<tr>
<td></td>
<td>(DOELAP notification)</td>
<td></td>
</tr>
</tbody>
</table>

If in the process of application, accreditation is valid until DOELAP notification.
EXTERNAL BLIND TESTING - INTER LAB COMPARISON

ORNL Performance Evaluation

Jan 09 -- Dec 11

Beta/Gamma Emitters

relative bias (%)

0

20

40

60

80

100

B E H I J K L M N P

lab code

CEMRC
**LIE DOWN AND BE COUNTED (LDBC)**

**Sign a research consent form**—the consent form gives legal permission to participate in the project and also verifies that you understand the study procedures. Such a form is required in all scientific research in which people are studied.

**View a 10-minute video** —the video explains the counting process step by step.

**Change into a special garment**—of all sizes and a private changing area with lockers for your clothing and valuables are available.

**Have your height and weight recorded**—these measurements enable scientists to estimate the thickness of your chest wall for calibration purposes.

**Lie Down and Be Counted**—inside the counting room, you'll recline on a bed. Detectors are located above and below the bed. It requires about 30 minutes for the measurements to be made. During that time you can relax, nap, or listen to your favorite music.

**Check Out**—once the measurements are completed, you may change back into your own clothes and research staff will explain the results.

Scientific research continues to improve the quality of our lives—contributing to our comfort and convenience, our safety, our health, and our happiness.

Citizen volunteers are vital to the research behind many of the technological advances that we count on today. Our lives have been enriched—and in many cases, prolonged—by their willingness to serve. In addition to the study of disease and its treatment, more and more people today are joining studies to help prevent disease and to make our homes and industries safer and healthier places in which to live and work. Every year an estimated half-million people become research volunteers in controlled studies. You have a unique opportunity to be part of this special group of individuals in your local community.

**Can we count on you?**

To schedule an appointment, or for more information on the program, please call Internal Dosimetry (575) 234-5530.

**NM State University**

A Division of the College of Engineering

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Fax: (575) 887-3051
cemrc@cemrc.org
https://cemrc.org/depts/internal-dosimetry

**Lie Down and Be Counted**

**Department Of Energy Program Since 1997**

Contact: (575) 234-5530
We need your help!

Believe it or not, behind the marvels and modern miracles of science are American citizens just like you. Many of the advances discovered by scientific researchers would not have been possible without the help of citizen research volunteers—dedicated individuals who gave their time to further the pursuit of knowledge.

Researchers at the Carlsbad Environmental Monitoring & Research Center need your assistance. They are studying:
- soil
- air
- water
- native plants
- and animals

in the region around the Waste Isolation Pilot Plant (WIPP).

This information will allow scientists to study both naturally occurring and man-made radionuclides present in the area. Sensitive monitoring equipment provides information about changes in radioactivity near the WIPP site. The baseline data collected prior to the opening of the facility will provide information for studies in the future. As more information is collected over the years, a detailed picture will emerge of environmental radiation in the Carlsbad area.

To complete this broad, comprehensive picture, scientists at the Carlsbad Environmental Monitoring & Research Center also have developed a research project.

LIE DOWN AND BE COUNTED (LDBC)

https://cemrc.org/depts/internal-dosimetry

We also come in contact with radioactive elements in nature and some radioactive elements that are man-made. Sources of radioactive material found in nature include minerals, oil, and gases. The man-made elements are primarily the result of above-ground nuclear tests conducted in the past by many countries world-wide or those administered for medical purposes. Scientists estimate that 52 percent of our exposure to radiation comes from natural sources.

The Internal Dosimetry Services Project is safe. No radiation is given off by the dosimetry instruments. It is similar to the studies conducted for the safety of workers in nuclear weapons facilities, power plants, and in other industries that employ radioactive materials.

How difficult is the job of a research volunteer? You decide!

There are 7 steps that you’ll be asked to follow.

Fill out a background questionnaire—by answering questions about your lifestyle and work habits, researchers will be able to more readily pinpoint the source of any radiation detected by the body counters. For example, have you ever worked in a nuclear power plant or weapons facility? (Note: Your answers to these questions will remain confidential. Information from the questionnaire will be used only for purposes of the Internal Dosimetry Project!)
LIE DOWN AND BE COUNTED (LDBC)

1. Schedule an appointment with the CEMRC Lung and Whole Body Counting Lab calling at 575-234-5530.

2. Arrive at time/date scheduled. View a 10 minute orientation video.

3. Fill out and sign a research consent form and a general questionnaire.

4. Change into clean scrubs in a private room with lockers for valuables.

5. Have your height and weight measured.

6. Lie Down and Be Counted for 30 minutes in a shielded chamber (closed room) listening to your favorite music.

7. Come out of the chamber at the end of the radiobioassay measurement, and change back into your clothes.

8. Finish the participation by listening to the review and explanation of the results.
• List of Elements (radionuclides) of which we look at in the Lung and Whole body in-vivo radiobioassay of the public participants.

<table>
<thead>
<tr>
<th>Carlsbad Environmental Monitoring &amp; Research Center</th>
</tr>
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<tbody>
<tr>
<td><strong>In-vivo Bioassay Lung and Whole Body Count Elements</strong></td>
</tr>
<tr>
<td><strong>Transuranic Elements</strong></td>
</tr>
<tr>
<td>Am – Americium</td>
</tr>
<tr>
<td>Cm – Curium</td>
</tr>
<tr>
<td>Cf – Californium</td>
</tr>
<tr>
<td>Np – Neptunium</td>
</tr>
<tr>
<td>Pu – Plutonium</td>
</tr>
<tr>
<td><strong>Fission, Activation Products</strong></td>
</tr>
<tr>
<td>Ba – Barium</td>
</tr>
<tr>
<td>Ce – Cerium</td>
</tr>
<tr>
<td>Cr – Chromium</td>
</tr>
<tr>
<td>Cs – Cesium</td>
</tr>
<tr>
<td>Co – Cobalt</td>
</tr>
<tr>
<td>Eu – Europium</td>
</tr>
<tr>
<td>Fe – Iron (Latin – Ferrous or Ferrie)</td>
</tr>
<tr>
<td>I – Iodine</td>
</tr>
<tr>
<td>Ir – Iridium</td>
</tr>
<tr>
<td>Mn – Manganese</td>
</tr>
<tr>
<td>Ru – Ruthenium</td>
</tr>
<tr>
<td>Sb – Antimony (Latin – Stibine)</td>
</tr>
<tr>
<td>Zn – Zinc</td>
</tr>
<tr>
<td>Er – Zirconium</td>
</tr>
<tr>
<td><strong>Natural Thorium and Uranium</strong></td>
</tr>
<tr>
<td>Th – Thorium</td>
</tr>
<tr>
<td>U – Uranium</td>
</tr>
<tr>
<td><strong>Natural Potassium</strong></td>
</tr>
<tr>
<td>K – Potassium (Latin – Kalium)</td>
</tr>
<tr>
<td><strong>Natural Radon</strong></td>
</tr>
<tr>
<td>Pb – Lead (Latin – Plumbum)</td>
</tr>
<tr>
<td>Bi – Bismuth</td>
</tr>
</tbody>
</table>
### In-Vivo Measurement Type

<table>
<thead>
<tr>
<th>Identification and Radioactivity Measurements of Radionuclides</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lung</td>
</tr>
</tbody>
</table>
| $^{241}\text{Am, }^{144}\text{Ce, }^{252}\text{Cf, }^{244}\text{Cm, }^{155}\text{Eu, }^{237}\text{Np, }$
| $238, 239, 240, 242\text{Pu, }228, 232\text{Th, }233, 234, 235, 238\text{U}$ |
| Whole Body                                                    |
| $^{133, 140}\text{Ba, }^{141}\text{Ce, }^{58, 60}\text{Co, }^{51}\text{Cr, }^{134, 137}\text{Cs, }$
| $152, 154, 155\text{Eu, }59\text{Fe, }131, 133\text{I, }192\text{Ir, }40\text{K, }$
| $54\text{Mn, }103, 106\text{Ru, }125\text{Sb, }232\text{Th, }88\text{Y, }$
| $65\text{Zn, }95\text{Zr}$ |
DOE/CEMRC ID In-vivo Lung and Whole Body Counting Basics
LIE DOWN AND BE COUNTED (LDBC)
LIE DOWN AND BE COUNTED (LDBC)
A DEPARTMENT OF ENERGY PROGRAM SINCE 1997

• Lie Down and Be Counted is the name of the outreach effort to get citizens involved in the Internal Dosimetry services project at CEMRC.
• By participating, you will also be helping scientists develop better, more sensitive monitoring equipment to protect those who work in the nuclear industry.
• Citizen volunteers are vital to the research behind many of the technological advances that enrich our lives.
• Every year an estimated half a million people become research volunteers in controlled studies.

A Division of the New Mexico State University College of Engineering

• To schedule an appointment, or for more information about the program, please call or leave a message for Internal Dosimetry at (575)-234-5530.
• Or email us at wbc@CEMRC.org
ACKNOWLEDGMENT

This work is funded by the financial assistance grant from the U.S. Department of Energy Carlsbad Field Office contract DE-EM0002423
REFERENCE


2) ANSI/HPS 13.30 2011 Performance Criteria for Radiobioassay