Part I – Science & Technology Behind Air Sampling & Monitoring

Forward

Chapter 1 – Overview – M. Hoover

Chapter 2 – Behavior of Aerosols & Gases – E. Sajo & M. Hoover

Chapter 3 – Review of Radioactivity, Detection & Measurement – M. Maiello
   [includes Radiation Safety (?)]

Chapter 4 – Basic Components of Air Sampling
   Overview – M. Maiello
   Filtration – M. Hoover
   Adsorption –
   Other Collecting Media -

Chapter 5 – Sampling Applications
   Workplace – J. Whicker (?)
   Stack – J. Glissmeyer
   Environmental – (?)
   Emergency Situations – T. O’Connell & WIPP personnel (?)

Chapter 6 – Calibration of Air Samplers – T. Voss

Chapter 7 – Sampler Placement - Jeff Whicker

Chapter 8 – Radon Interference & CAM – N. Harley & (perhaps J. Rodgers)
   Harley for Rn and progeny details, decay and interference
   Rodgers for algorithm corrections, CAM design, alarm strategy

Chapter 9 – Special Aerosol Characterization Techniques – M. Hoover

Chapter 10 – Review of Nuclear Fallout – H. Beck

Chapter 11 – Introductory Internal Dosimetry - G. Potter

Part II – Standards, Regulations and Air Sampling Support

Chapter 12 – National and International Instrument Standards – F. Morgan Cox

Chapter 13 – Regulations Relevant to Radioactive Air Sampling – C. Jones

Chapter 14 – Emergency Situation Sampling – T. O’Connell
Part III – Methods for Radioactivity of Importance

Method 1- Gross Alpha
Method 2 –Gross Beta
Method 3A- Tritium
Method 3B – Tritium Oxide
Method 4 – Carbon 14
Method 5 – Iodine
Method 6 – Gamma-Emitters
Method 7 – Radon
Method 8 - Plutonium
Method 9 – Personal Air Sampling

Glossary - Maiello

Appendix I – Radionuclide Characteristics - Maiello

Appendix II – Internet Resources -
Radioactive Air Sampling (and Monitoring) Methods

Summary of April 4, 2006

Points of Discussion on 3/4:

- Ambient vs. Standard correction (whither STP?)
- Sampling and Monitoring are discussed in the book
- Isokinetics in stack sampling: does not apply in all cases

1. Stack Sampling Chapter: considerations
   a. ANSI 13.1 (1999) presents issues for implementation
      i. Paul Frame to M. Maiello: ANSI 13.1 is not the way stack sampling is done
      ii. Comment may refer to easier to use older version of std. Vs. 1999 version
      iii. AMUG participants: No air sampler placement instructions in 13.1
   b. Section should be written, how? Suggestion: as a survey section.
      i. **Need: an outline of this section from John Glissmeyer.**

2. Standards: considerations
   a. Instrument based
   b. International in coverage
   c. Book discusses the science of air sampling. Instruments are not covered in any great detail.
   d. Section should be written, how?
      i. Suggestion: include an explanation of –
         1. need for standards (need for quality results)
         2. dynamic situation re: standards (constant renewal)
         3. Mark Hoover: Provide list of air sampling vendors (justifies section)

3. Regulations: Suggested chapter or section
   a. Potential author: Cindy Jones, NRC
   b. Contents: US regs concerning radioactivity in air (NRC & Agreement State regs; EPA regs; any others?)

4. Radiation Safety Chapter – M. Maiello
   a. Where to put it?
      i. Appendix? (sends message of less importance)
      ii. With the other chapters (sends message of more importance)
      iii. Part of Review of Radioactivity Chapter
5. “Measurement Overview” or Preface
   a. Mention sampling objectives:
      i. To calculate dose
      ii. Should have text and organization that follows the final Table of Contents (TOC)

6. TOC: most important suggested change -
   Chapter 6– Sampling Train (multiple authors)
   Overview – M. Maiello
   Filtration – M. Hoover
   Adsorption –
   Other collecting media (cold traps, chemical bubbling) -

   Chapter 7 - Sampling Applications
   Workplace
   Stack Sampling
   Environmental
   Emergency

7. Physics of Aerosols and Behavior of Aerosols & Gases
   a. E. Sajo and M. Hoover to work together to produce a single chapter

8. Introduction to CAM – J. Rodgers
   a. Not a method (as was before), but an intro to CAM
   b. Advances in CAM might be mentioned

9. Combine Rn and CAM
Radiation Protection Program

Gary H. Zeman
Radiological Safety Officer
Argonne National Laboratory
December 2, 1942 -- Enrico Fermi's team produces the world's first sustained nuclear chain reaction at University of Chicago's Stagg Field.

March 20, 1943 -- Chicago Pile 2 achieves criticality. It was CP-1, Fermi's first reactor, dismantled and reassembled at the Argonne Forest site in the Cook Country Forest Preserve.
Chicago Pile 2

Chicago Pile 3

Chicago Pile 5

The Zero Power Physics Reactor
Hot Cell Facilities

Characterization and testing of irradiated materials are carried out in the Alpha-Gamma Hot Cell Facility
The Advanced Photon Source (APS) is a synchrotron light source that produces high-energy, high-brilliance x-ray beams.

The Intense Pulsed Neutron Source (IPNS) is a national facility for neutron scattering research.
United States Department of Energy
Office of Public Affairs
Washington, D.C. 20585

NEWS MEDIA CONTACT:
Craig Stevens, 202/586-4940

FOR IMMEDIATE RELEASE
Monday, February 6, 2006

Department of Energy Announces New Nuclear Initiative
Global Nuclear Energy Partnership to expand safe, clean, reliable, affordable nuclear energy worldwide

WASHINGTON, DC – As part of President Bush’s Advanced Energy Initiative, Secretary of Energy Samuel W. Bodman announced today a $250 million Fiscal Year (FY) 2007 request to launch the Global Nuclear Energy Partnership (GNEP). This new initiative is a comprehensive strategy to enable the expansion of emissions-free nuclear energy worldwide by demonstrating and deploying new technologies to recycle nuclear fuel, minimize waste, and improve our ability to keep nuclear technologies and materials out of the hands of terrorists.
Radioactive Air Sampling

Methods

Mark L. Maiello, Ph.D.
R&D Environmental Health & Safety

April, 2006
Argonne National Laboratory
U.S. Department of Energy
Greetings

• Thank you…
  ‣ For making Radioactive Air Sampling Methods the Topic for the 18th AMUG Meeting
  ‣ For inviting me to your meeting
  ‣ For inviting me back to a DOE facility (1st time at Argonne Nat’l Lab)
  ‣ Former U.S. DOE employee…my wife is employed at US DHS/EML in NYC

• Regrets:
  ‣ Mark Hoover with us electronically only (but can do 3 days)
  ‣ Maiello here only for 2 days (both due to travel budget restrictions).
Mark Maiello
A Brief Introduction

- Radiation Safety Officer – Pearl River, NY Facility
- Former US DOE physical scientist: 1986-1990
  - Environmental Measurements Laboratory, New York City
- Environmental Remediation
  - CoPhysics Corporation, Orange County, NY
- New York University
  - Institute of Environmental Medicine, Ph.D., 1986
    - Radon Daughter Measurements w/ electrostatic collection & TLDs
- Memberships:
  - Health Physics Society (1981 (Student/Teacher Workshop Committee, History Comm), American Nuclear Society, Sigma Xi, NY Academy of Sci
- Health Physics News
  - Contributing Editor (currently)
  - Approx. 40 publications (radon, environmental background, homeland security, editorials)
- Contributor to Aerosols Handbook by L. Ruzer and N. Harley (CRC, 2005)
Wyeth Research

- **Wyeth Research**
  - Pharmaceutical, biotech, consumer health care and animal health care R&D company & manufacturer
    - Centrum vitamins, Chap Stick, Robitussin, Anbesol
    - Mylortarg (cancer), Enbrel (arthritis), Effexor (depression)

- **Air Monitoring: Radiosynthesis Laboratories**
  - Use of H-3 and Carbon-14 in organic chemistry procedures (syntheses)
  - Experimental compounds are tagged with either isotope for metabolism studies
  - Roughly 3.5 Ci of H-3 or 200 – 300 mCi of C-14 are used per synthesis
  - Permitted emission point (New York State DEC) with emissions limits of 800 mCi (C-14), 5000 mCi H-3.
  - Daily stack sampling required using gas bubbling system for C-14 and H-3 (augmented w/ H-3 ion chamber)
Radioactive Air Sampling Methods
The Book’s History

- 1993 or 1994: Andrew Hull (BNL) put out a call for assistance w/ the updating of the Radioactive Air Methods Chapter of *Methods of Air Sampling and Analysis, 4th Ed.*, by James P. Lodge, Jr.
  - Which Health Physics Meeting did he do that?
    - 38th in Atlanta or the 39th in San Fran?

- July 13, 1994
  - Maiello agrees to assist Andy Hull, then chair of Subcommittee 8 of the Intersociety Committee.

- June 2, 1995
  - Maiello made chair of Subcommittee 8 (Andy steps down)
Radioactive Air Sampling Methods
A Brief Long History

- Intersociety Committee (ISC)
  - Previous Subcommittee 8 (Radioactive Compounds) Chairs:
    - Bernard Shleien, Donald C. Bogen (EML), and Andy Hull (BNL).

- 3rd and 4th edition Editor: James P. Lodge

- Executive Secretary (ISC): Richard J. Thompson
Radioactive Air Sampling Methods
Brief Long History

- Work progressed on the book thru 1995 to 2001 with at least 2 mark-up sessions
- Hull passes away in March, 1999
- Lodge passes away December 14, 2001
- Exec. Sec., Dick Thompson, in poor health, passes torch to Dr. Judith Chow (Desert Research Inst, Las Vegas) and Dr. Delbert Eatough (Brigham Young University)
- March, 2001: torch still burning
- Along about December, 2003, indications that Chow and Eatough drop the torch (no further contact since that time)
- March 2004: Maiello inquires if CRC would be interested in publishing Radioactivity Methods as stand alone book...encouraged
Radioactive Air Sampling Methods
Brief Long History

- Spring 2004: Maiello informs Subcommittee 8 contributors of intention to send CRC a book proposal
- Spring 2004: Hoover jumps on board
- May 2004: Maiello writes book proposal and submits to CRC
- July 2004: reviews of proposal received and answered...**Good news:** book approved!
- End of 2004: contract w/ CRC signed
- **Bad news:** Thanksgiving 2005: Hoover & wife suffer car accident!!!
- **More “bad news:”** book to be finished in 2006!
- April 2006: 18th Annual AMUG Meeting
- **Moral:** Almost 12 years of hanging on might pay off!
Radioactive Air Sampling Methods
Deadline

- **Winter 2006: Deadline**
  - Reasons: Contractual agreement with CRC
  - Marketing and promotion of the book affected
  - Must show CRC we’re reliable if we want to do a 2nd Ed.

- **Objective:**
  - The book is an introduction to the subject matter
Draft Chapter: “The Practice of Continuous Air Monitoring for Alpha-emitting Radionuclides”

John C. Rodgers, CHP
Canberra Aquila
8401 Washington Pl. NE, Albuquerque, NM 87113
505-796-3835    jrodgers@aquilagroup.com

AMUG Meeting, April 4, 2006
Argonne National Laboratory
Chapter Contents

1. Principles
2. Application
3. Sensitivity and range
4. Interference effects & control
5. Precision, Accuracy, and Bias
6. Apparatus
7. Alpha CAM utilization
8. Calibration
9. Calculations
10. Cautions
Principles of Continuous Monitoring

Continuous Monitoring

inlet design for ‘representative’ sampling

i.e., \(0.1 < d_p < 15 \mu m\) AED
real-time alpha-detection and flow measurement
automated background correction
alarm capability w/o unacceptable FAR

Sampling
open face filter holder – all particle sizes
provides sample of record for dosimetry
no detection or flow measures
Application

With proper design & placement, provide reliable early detection to optimize worker protection

Real-time net TRU concentration (DAC)

Integrated Potential Exposure (DAC-hr)

\[
DAC = \frac{ALI}{2400} \quad (\mu\text{Ci/m}^3)
\]

\[
DAC\text{-hr} = DAC \times \text{Filter sample time}
\]
Sensitivity

...A function of sampling rate, background, correction method, dust loading, count integration time, ...

Decision Level  = 1.65 * (N_s + 2*N_b)^{1/2}

MDA = 4.65 * \sigma_b where \sigma_b is determined from procedure blank data

Expectation ~ 8 DAC-hr (under lab conditions?)

.... but at what False Alarm rate?
Precision, Accuracy, Bias

**Precision** refers to the degree of agreement in a series of measurements of the same quantity (cluster about avg.)
(precision is desirable but does not guarantee accuracy !)

**Accuracy** is the closeness of measurements to a conventionally true value (…. not often determined using TRU aerosols)

**Bias** is clustering of measurements that systematically deviate (larger /smaller) from a conventionally true value (… shows up when calibration and setup are different from applied conditions)

**All of these factors can depend on sampling conditions (Rn background, dust loading) as well as instrument design, calibration, and use**
Alpha CAM data: Concentration

\[ C_{pu}(T_i) = T_i \times [A(T_i) - A(T_{i-1})] / [T_c^2 \times \text{eff} \times K \times V] \]

(procedure blank)
\[ \text{DAC-hr} = T_i \times A(T_i) / [T_c \times K \times V \times \text{eff} \times ZDAC] \]

10 min integration time/ cycle: Avg. = -0.39 DAC-hr

30 min integration time / cycle: Avg = 0.005 DAC-hr
(procedure blank)
Interference control: 
Background Correction

Peak centroid + channel ROI count ratios:
\[ Pu \ (ROI-1) = (ROI-2) \cdot K \cdot (ROI-3)/(ROI-4) \], ROI() = counts, K = cal. Const.

Peak centroid + valley channels + exponential tail fit overlap into Pu-ROI
\[ Pu = Y1 - T_{8.78} - T_{7.68} - T_{6.05} \], Ti = exponential tail count in Pu ROI
\[ Y1 = \text{Gross count in Pu ROI} \]

Peak centroid + Peak function fits
\[ \text{Peak } k = A_k \cdot \sum t_i \cdot [t_i \cdot \exp(f1) \cdot \text{erfc}(f2)] \]
\[ f1 = f(x, t_i, \mu, \ldots), f2 = f(x, t_i, \mu, \ldots), x = \text{channel no.}, \]
\[ t = \text{fitting parameter, } \mu = \text{peak centroid channel no}, \]
\[ A = \text{peak amplitude, erfc}[] = \text{complementary error function} \]

Other methods ?? Gaussian + exponential tail .... ?
Background correction spectra
CAM design & utilization

CAM inlet design to efficiently capture larger particles significantly improves performance.
But CAM performance compromised by poor placement in the work environment.
Use of sample extraction/transport lines further diminishes performance due to line losses.
Choice of filter media impacts spectrum analysis.
Maintaining adequate sample flow rate a factor.
A final thought …

“Radiological air monitoring is not for dabblers…”

George Newton
Conducting Airflow Studies for Improved Air Quality Measurements

Jeffrey J. Whicker, PhD

Los Alamos National Laboratory
Health, Safety and Radiation Protection Division
Aerosol and gas dispersion patterns are highly time dependent and spatially heterogeneous.

Airflow and aerosol dispersion indoors is highly complex and poorly understood, yet it drives human exposure and detection.
Placement of air samplers and monitors relative to airflow: 10 CFR 835

- Identity potential exposures and verify effectiveness of engineering and other controls in containing radioactive material.
- Real-time air monitoring needed where individual likely to be exposed > 40 DAC-hrs in a year or where there is a need to detect and alert workers of increased concentrations.
  - Need sufficient sensitivity to alert workers to action
    - Instrument
    - Placement
What is required by regulations: DOE Implementation Guide for Air Monitoring

• “Proper strategy for the placement of real-time air monitors is critical to the effectiveness of the air monitoring program.”

• “The number and placement of real-time monitors should be optimized.”
  – Balance worker protection against cost

• Reevaluation needed (3 yrs or when there is a significant change in the room)
Gas and aerosol dispersion dynamics

Transport Mechanisms*

1) Molecular Diffusion (0.0008 cm/s)
2) Gravitational Settling (0.003 cm/s)
3) Turbulent Diffusion (> 0.2 cm/s)
4) Room Airflow (> 1 cm/s)

*Rates based on 1 µm diameter particles at STP

Conclusion: Gas and aerosol dispersion dynamics are driven primarily by room ventilation and associated airflow
NUREG-1400 guidance

• Qualitative studies-
  – visual observations, e.g. smoke, balloons
  – record by drawing or video

• Quantitative studies-
  – release tracer and measure concentrations over time and space
  – air velocity measurements (thermal or sonic anemometers)
Criteria for ventilation-induced airflow

- Negative differential between ventilation zones of different potential for airborne releases
- Local exhaust ventilation (e.g., hoods)
- Rapidly remove released material from breathing zones of workers and exhaust from room
Placement of samplers has to be integrated with airflow patterns

How much of the released material gets to the sampler/monitor?

How quickly does the released material get to the monitor?
Particle cloud transport
Airflow studies reveal optimal placement strategies to balance safety with cost

General considerations for airflow studies

• Selection of aerosol generator
  – Particle size
  – Thermal gradients
  – Energy of release
  – Puff verses continuous release

• Room conditions
  – People in room
  – Temperature
  – Ventilation rate
  – Equipment layout
  – Representative of other rooms?
Conclusion: Good Progress

• First draft of the chapter is almost complete
• Goal is to make this chapter useful for practitioners, not just a review of the literature
• Needs better organization
• Balance of detail/generalities needs review
CALIBRATION OF DETECTORS

TRACEABILITY

REPEATIBILITY

AUDITABILITY

QA PROGRAM

AS FOUND

CONTROL CHARTS

RECOMMENDED CALIBRATION SOURCES

ALTERNATE CALIBRATION SOURCES

ALTERNATE CALIBRATION METHODS

LABORATORY INTERCOMPARISONS

ENVIRONMENTAL EFFECTS

ALPHA PARTICLE ENERGY CALIBRATION

BETA PARTICLE ENERGY CALIBRATION
CALIBRATION OF AIR SAMPLERS

ROTAMETERS,
HEATED WIRE MASS FLOW METERS,
dP SENSORS,
ROTATING VANE,
ANY OTHERS

TRACEABILITY

REPEATIBILITY

AUDITABILITY

QA PROGRAM

   AS FOUND

   CONTROL CHARTS

ALTERNATE CALIBRATION METHODS

LABORATORY INTERCOMPARISONS

ENVIRONMENTAL EFFECTS
AMERICAN NATIONAL STANDARDS INSTITUTE & INTERNATIONAL ELECTROTECHNICAL COMMISSION (ANSI & IEC) AIR MONITORING STANDARDS

PRESENTED AT THE
18TH ANNUAL AMUG MEETING
ARGONNE NATIONAL LAB
4-6 APRIL 2006
ANSI N42 AIR MONITORING STANDARDS

• ANSI N42 323C FOR TEST & CALIBRATION; CO-CHAIRS MICHELLE JOHNSON AND MARK HOOVER; CURRENTLY IN N42 DISTRIBUTION FOR GENERAL REVIEW, COMMENTS AND BALLOT. SOME CONTRIBUTORS ARE PRESENT.

• ANSI N42.17B-1989 NOW 15 PLUS YEARS OLD AND NEEDING REVISION; ALSO NEEDS A CHAIR OR MORE AND ACTION SOON.

• ANSI N42.18-1980 ON-SITE MONITORING; NEEDS REVISION; BILL BARTLETT NOW CHAIR; NEED PROGRESS REPORT.

• ANSI N42.30-2000 TEST & CAL FOR TRITIUM; NEEDS REVIEW FOR REAFFIRMATION OR REVISION.
• IEC 60761 (2002) IN FIVE PARTS:

• IEC 60761-1 PART 1 GENERAL REQUIREMENTS;
• IEC 60761-2 PART 2 SPECIFIC REQUIREMENTS INCLUDING MONITORING FOR TRANSURANICS;
• IEC 60761-3 PART 3 FOR MONITORING NOBLE GASES;
• IEC 60761-4 PART 4 FOR MONITORING IODINES; &
• IEC 60761-5 PART 5 FOR MONITORING TRITIUM.
• THESE STANDARDS COVER ONLY EFFLUENTS.
NEW IEC AIR MONITORING STANDARDS BEING DEVELOPED

• THESE NEW STANDARDS COVER MONITORING IN THE WORKPLACE, IN EFFLUENTS AND IN THE ENVIRONMENT (ALL APPLICATIONS):

  • IEC 62302 INSTRUMENTATION FOR MEASURING NOBLE GASES; CHAIR- M COX;

  • IEC 62303 INSTRUMENTATION FOR MEASURING TRITIUM; COCHAIRS A KLETT (DE) AND M COX.

• THESE TWO STANDARDS WILL BE PUBLISHED IN THE NEXT YEAR.
NEEDED NEW IEC AIR MONITORING STANDARD

• IEC 62XYZ INSTRUMENTATION FOR MEASURING RADIOACTIVE AIRBORNE PARTICLES; NEW CHAIR AND NEW COMMITTEE NEEDED.
NEEDED NEW ANSI AIR MONITORING STANDARDS

• THE NEWER IEC STANDARDS SHOULD SERVE WELL AS MODELS FOR NEEDED ANSI STANDARD FOR NOBLE GAS MONITORING. THERE IS CURRENTLY NO RELEVANT ANSI STANDARD.

• THE NEW IEC SERIES 61578 IN FOUR PARTS FOR MONITORING RADON AND RADON PROGENY CAN ALSO SERVE AS MODELS FOR A RELEVANT ANSI STANDARD(S). HERE WE NEED A CHAIR AND A COMMITTEE TO RESTART ANSI N42.21.
An Introduction to Bladewerx LLC
Bladewerx is a nuclear instrumentation company specializing in designing, manufacturing, and supporting products that solve specific customer radiation monitoring needs.
Company History

- **2001**: Began life providing software consulting to instrumentation vendors. Our corporate headquarters: a garage on the West Mesa in Albuquerque.
- **2003**: Bladewerx introduces the industry’s first ‘wearable’ alpha CAM—the *SabreBZM™* Breathing Zone Monitor.
- **2004**: Our first profitable year (and the trend continues!)
- **2005**: We relocate to our current palatial facility in Rio Rancho
Bladewerx is located just down the road from Intel’s Pentium Fab in Rio Rancho (a suburb of Albuquerque)

- 800 sq. ft. offices
- 800 sq. ft. lab and assembly area
Technology History

- Bladewerx developed the software for the first commercial instrument that employed real-time peak fitting for radon compensation in an alpha air monitor.
- The SabreBZM was the first commercial use of a PocketPC in a rad-protection instrument.
Bladewerx Expertise

- Over 50 years of combined experience designing and building radiation monitoring instrumentation
- Unique ability to combine hardware and software solutions in compact and economical systems
- Alpha air monitoring and low-level counting statistics
- Development of high performance data analysis algorithms such as radon background compensation through peak-shape fitting to enable state-of-the-art sensitivity in air monitoring applications
- Incorporation of PDA’s (as well as WinCE embedded boards) into portable instrumentation systems capable of data collection, analysis, and archiving
- A design philosophy that accommodates rapid technology change in commercially available PDAs and embedded boards
- Products that solve specific customer needs coupled with a high level of support
David K. Baltz has over twenty years experience in software design and development, and was a design engineer for Thermo Electron for 13 years before leaving to start his own company. He was the founder and president of Metalman Corporation, an innovator in the mechanical computer-aided-design market. Before starting Bladewerx, Mr. Baltz served as a consultant to Thermo Electron, spending three years developing the instrument and client software for the state-of-the-art Thermo Eberline Alpha-7 continuous air monitor.
Don Hanna, Managing Partner

- Don Hanna brings to Bladewerx experience of more than twenty years in design engineering, engineering management, and general management. He is past-President of National Nuclear Corporation, Thermo Eberline and two other Thermo Electron Corporation subsidiaries. A Kansas State graduate in electrical and nuclear engineering, Don brings to Bladewerx a solid technological knowledge base in the radiation protection and measurement field, complemented by critical management experience.
William Brown, III

- Bill Brown adds over 30 years of electronics design experience to the product development arsenal of Bladewerx. At home in both analog and digital design, Mr. Brown spent 9 years with Thermo Electron before taking over design and development at Santa Fe-based, Eco Sensors, a leading manufacturer of ozone monitoring sensors. He was the lead designer of the Bladewerx SabreMCA™ multi-channel analyzer.
Bladewerx Family

- **Technician**
  - Kyle Thomas, completing an Associate degree in Electronics Technology
- **Field Service Engineer**
  - Al Briggs with 30 years engineering experience
- **Accounting and Purchasing**
  - Roxanne Baltz
- **Key Vendors include BetaTron Electronics, Precision Components, CNC Lathe, and countless Web-based component providers**
Bladewerx Products

- Home Grown
- Collaborations
Bladewerx Designed and Built Products

- **SabreBZM™** Breathing-Zone Monitor
- **SabreAlert™** Portable Workplace Monitor
- **SabreASC™** Alpha Sample Counter
- **SabrePSC™** Portable Sample Counter

All products feature the Bladewerx isotope peak-fitting algorithm that provides significantly improved performance over regions-of-interest and tail-fitting methods for radon daughter compensation.
**SabreBZM™ Breathing Zone Monitor**

- Compact and “wearable” at 2.6 lbs
- Performs both fast-responding (Acute) and high-sensitivity (Chronic) measurements with typical sensitivities of 45 DAC-Hr (Acute) and 1.5 DAC-Hr (Chronic)
- 3 LPM internal pump
- 8 hours battery operation
- Voice annunciation of status changes and dose provide hands-free operation
- DAC, DAC-Hr, and spectrum logging, selectable SI units
- Wireless 802.11b network option for RadNet compliance
All the features of the *SabreBZM* including:

- High-performance sample collection head
- Available with 3 LPM or 6 LPM internal pump
- Easily portable at 5.2 lbs including internal battery
- Can be plumbed to house vacuum or external pump.
Typical *SabreBZM™* and *SabreAlert™* Display

- Isotope of interest (or radon progeny) current reading and status
- Selectable display of dose, concentration and activity
- Peak Acute readings
- Battery life indication
- View spectrum
**SabreASC™ Alpha Sample Counter**

- Activity determinations for up to two different isotopes along with our unique isotopic analysis feature that “matches” an unknown peak to a known list of isotopes.
- Automatic count time determination with complete data and spectrum logging.
- Configurable display with three independent windows for activity/status; real-time strip-chart display of activity, detection limit, action level, and elapsed time; and spectral display.
Typical *SabreASC™* Display
All the features of the *SabreASC* plus

- Complete counting system built-in to a rugged carrying case
- Rechargeable battery
- PDA running the *SabrePSC Assistant Software*
Collaboration Projects

- Custom software incorporating Bladewerx SabreMCA and peak fitting algorithms into the client’s CAM product
- Custom hardware and software design for a portable survey instrument implementing the client’s specific needs for simplicity and data logging
- Custom software design interfacing to the client’s ion chamber to enable rad mapping and data logging
- Custom data analysis software for a client’s neutron dosimeter
- Custom version of the SabreAlert with communication software enabling remote data acquisition
Who do we work with?

- Our customers include most of the DOE Laboratories, D & D sub-contractors, as well as foreign entities like ARPANSA (Aus.)
- We have provided design services and/or co-developed products with several companies including Thermo, Lab-Impex, Technical Associates, XIA, and Bartlett Services.
And, what’s with the name?

Mr. Baltz, not wanting to name a company after himself, went back to the distant past when he knew a wild young engineer, moonlighting as a competition hang-glider pilot and sporting a Mohawk. The company is named after that young rebel who went by the name, *Bif Blade*.

FOR MORE INFO...

*Visit Bladewerx on the internet at:*

[www.bladewerx.com](http://www.bladewerx.com)
Corporate Facilities

Founded in 1979, F&J SPECIALTY PRODUCTS, INC. is a manufacturing and services company located in the beautiful horse country of Ocala in Marion County, Florida.
Corporate Facilities (cont.)

F&J’s facilities consist of 23,000 square feet in three buildings on a 2.3 acres

- [Image of corporate facilities]
- [Image of corporate facilities]
F&J employs 21 persons.

Their experience levels within the company are:

- 5 employees with > 20 years
- 7 employees with > 9 years
- 9 employees with > 6 years
F&J Electrical Safety Product Certifications

F&J has the following certifications

• Electrical Safety Certifications for UL, CSA and CE standards for digital airflow calibration systems, high volume and low volume air sampling systems, tritium collection systems and the new AC/DC portable air samplers

• Over 360 products have been certified
ISO 9001 Quality Policy Statement

With customer satisfaction as our primary goal,

F&J SPECIALTY PRODUCTS, INC. is committed to:

- Meeting or exceeding our customer's requirements
- achieving excellence in all of our efforts
- maintaining high quality, safety and reliability standards.

Through CONTINUOUS IMPROVEMENT, we work as a team to deliver quality products and services to all our customers.
F&J Company Focus

Present and Future Focus

Enhancing existing digital air monitoring and air flow calibration systems with communications options and integration with other instruments via a central data acquisition and data processing system.

Upgrading hardware and software systems to implement new technologies and to address new customer requirements. Development of portable and fixed station high volume air sampling systems with multiple features to enhance the accuracy and facilitate the collection of air monitoring data.
Homeland Security Focus

- Self-contained emergency air sampling systems which include air samplers, consumables, calibration instrument(s), adaptors, tools and a storage/transportation case
  - Instrumentation for extreme operating conditions
  - Lightweight, portable air sampling instruments operating on long life batteries, DC voltage or conventional line power.
F&J Calibration Services

Calibration Services
(NIST Traceable)

• Airflow Calibrators

• Air Monitoring Systems

Calibrations to four different reference temperatures

<table>
<thead>
<tr>
<th>Calibration</th>
<th>Temperature</th>
</tr>
</thead>
<tbody>
<tr>
<td>Classical Standard T and P (STP)</td>
<td>0°C (32°F)</td>
</tr>
<tr>
<td>Normal T and P (NTP)</td>
<td>20°C (68°F)</td>
</tr>
<tr>
<td>USA Modified Normal T and P (MNTP)</td>
<td>21.1°C (70°F)</td>
</tr>
<tr>
<td>Standard Ambient T and P (SATP)</td>
<td>25°C (77°F)</td>
</tr>
<tr>
<td>Reference P (for all the above)</td>
<td>1 atmosphere, 760 torr, 101.325 kPa</td>
</tr>
</tbody>
</table>
The OCCUPATIONAL SAFETY AND HEALTH ADMINISTRATION (OSHA) has the authority and responsibility to set standards for laboratories to perform testing on products or equipment to confirm electrical product safety.
OSHA approved laboratories are designated as:

Nationally Recognized Testing Laboratory (NRTL)

CFR, Title 29 Part 1910 Chapter 7

“NRTL is an organization which is recognized by OSHA in accordance with Part A of this section and which tests for safety and lists or labels or accepts equipment or materials and which meets all of the following criteria…”
Examples of NRTLs

- TUV America
- Intertek Testing Services
  (formerly Edison Testing Laboratories)
- Underwriters Laboratory

Over 18 companies in USA are currently recognized as NRTLs.
Occupational Safety and Health Administration (OSHA) (cont.)

OSHA requirement for Nationally Recognized Testing Laboratory Approval of Products

http://www.osha.gov/dts/otpca/NRTLarticle.html

Nationally Recognized Testing Laboratory Program

F&J Air Sampler Systems Bearing the \(^{\text{c}}\)ETL\(_\text{US}\) Mark

Digital Flowmeter Low Volume Air Samplers

<table>
<thead>
<tr>
<th>Model</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>DF-1</td>
<td>DFM-100 Series (15 models)</td>
</tr>
<tr>
<td>DF-14M</td>
<td>DF-34M</td>
</tr>
<tr>
<td>DF-22</td>
<td>DF-134</td>
</tr>
<tr>
<td>DF-2234</td>
<td>DFM-10034 (10 models)</td>
</tr>
</tbody>
</table>
F&J Air Sampler Systems Bearing the $\text{CETL}_{\text{US}}$ Mark (cont.)

Digital Flowmeter High Volume Air Samplers

DFHV-1  DFHV-1S
DF-604   DF60810
DF-804   DF-804-30
F&J Air Sampler Systems Bearing the \text{CETL}_{\text{US}} Mark (cont.)

Digital Flowmeter AC/DC A/C Samplers

DF-40L-8
DF-40L-12
DF-AB-40L
F&J Air Sampler Systems
Bearing the $\text{CETL}_\text{US}$ Mark (cont.)

Digital Flowmeter Tritium Collection Systems

TCS-3000

TCS-5000
F&J Air Sampler Systems
Bearing the CE Mark (cont.)

Analog Low Volume Air Samplers

<table>
<thead>
<tr>
<th>LV-1</th>
<th>LV-1D</th>
<th>LV-14M</th>
</tr>
</thead>
<tbody>
<tr>
<td>LV-134M</td>
<td>LV-134</td>
<td>LV-119</td>
</tr>
<tr>
<td>LV-2</td>
<td>LV-22</td>
<td>LV2234</td>
</tr>
<tr>
<td>FJ28B</td>
<td></td>
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</tr>
</tbody>
</table>
**F&J Air Sampler Systems**  
**Bearing the CE Mark (cont.)**

Digital Programmable Low Volume Air Samplers

<table>
<thead>
<tr>
<th>Model</th>
<th>Model</th>
<th>Model</th>
</tr>
</thead>
<tbody>
<tr>
<td>DL-1</td>
<td>DL-118</td>
<td>DL134</td>
</tr>
<tr>
<td>DL14M</td>
<td>DL-34M</td>
<td>DLM100 series</td>
</tr>
<tr>
<td>DL-2</td>
<td>DL-22</td>
<td>DL2234</td>
</tr>
<tr>
<td>DL-28B</td>
<td>DL-1V.2</td>
<td>DL118V.2</td>
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<tr>
<td>DL134V.2</td>
<td>DL14MV.2</td>
<td>DL34MV.2</td>
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<tr>
<td>DLM100V.2 series</td>
<td>DL-2V.2</td>
<td>DL-2V.2</td>
</tr>
<tr>
<td>DL2234V.2</td>
<td>DL-28BV.2</td>
<td>DL-22V.2</td>
</tr>
</tbody>
</table>

![Image of air samplers](image-url)
F&J Air Flow Calibrator Systems Bearing the {ETLUS} Mark (cont.)

**Mini-Calibrators**

<table>
<thead>
<tr>
<th>Model</th>
<th>Volume (L)</th>
</tr>
</thead>
<tbody>
<tr>
<td>MC-300CC</td>
<td></td>
</tr>
<tr>
<td>MC-3L</td>
<td></td>
</tr>
<tr>
<td>MC-25L</td>
<td></td>
</tr>
<tr>
<td>MC-60L</td>
<td></td>
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<tr>
<td>MC-175L</td>
<td></td>
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<td>MC-500CC</td>
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<td>MC-30L</td>
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<td>MC-75L</td>
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<td>MC-15L</td>
<td></td>
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<tr>
<td>MC-115L</td>
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</table>
F&J Air Flow Calibrator Systems
Bearing the CE Mark (cont.)

Digital Airflow Calibrator Family; Compact Digital Design

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td>CD-801</td>
<td>CD-802</td>
<td>CD-812</td>
</tr>
<tr>
<td>CD-828</td>
<td>CD-814</td>
<td>CD-530</td>
</tr>
<tr>
<td>CD-540</td>
<td>CD-550</td>
<td>CD-870</td>
</tr>
<tr>
<td>CD-801B</td>
<td>CD-802B</td>
<td>CD-812B</td>
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<td>CD-828B</td>
<td>CD-814B</td>
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<td>CD-812AS</td>
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<td>CD-540ASB</td>
<td>CD-550ASB</td>
<td>CD-870ASB</td>
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<td>CDL3L</td>
<td>CDL10L</td>
<td>CDL1</td>
</tr>
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<td>CDL3</td>
<td>CDL10</td>
<td>CDL30</td>
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<td>CDL3IB</td>
<td>CDL10LB</td>
<td>CDL10LB</td>
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<tr>
<td>CDI1B</td>
<td>CDL10B</td>
<td>CDL30B</td>
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### Digital Airflow Calibrator Family; Counter Top Design

<table>
<thead>
<tr>
<th>Model</th>
<th>Model</th>
<th>Model</th>
</tr>
</thead>
<tbody>
<tr>
<td>D-801</td>
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<td>D-812</td>
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<tr>
<td>D-828</td>
<td>D-814</td>
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<td>D-802B</td>
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<td>D-550ASB</td>
<td>D-870ASB</td>
</tr>
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<td>DL10L</td>
<td>DL1</td>
</tr>
<tr>
<td>DL3</td>
<td>DL10</td>
<td>DL30</td>
</tr>
<tr>
<td>DL3LB</td>
<td>DL10LB</td>
<td>DL1B</td>
</tr>
<tr>
<td>DL1-B</td>
<td>DL30B</td>
<td></td>
</tr>
</tbody>
</table>
Monitors for Radioactivity in Air

DOE AMUG
April 2006
Historical Perspective

- Radiation monitors for more than 50 years!
- A couple of “older” models…
Types of Monitors

- Alpha in air monitors
- Beta in air monitors
- Environmental monitors
  - With HPGe detectors for isotopic analysis
- Moving filter monitors
- Moving monitors (portable systems)

- Separate Air Quality Group
- EPA compliance monitors
- Particulate monitors
- Hazardous gases
AMS-4
Beta in Air Monitor

- Remote Heads
- Particulate, Iodine, Noble Gas measurements
- In-Line for stack sampling
- Radial Entry for ambient air
- Noble Gas
- Very portable with attached pump module
- Also used for installed monitoring
- Wireless communications for ease of use during hot jobs or outages
Alpha-7A and L
Alpha in Air Monitor

- PC-based alpha in air monitor
- Equations updated once per second
- Measures 8 isotopes simultaneously
- Separate alarms for each isotope
- Smart remote detector heads
- Easily networked
- New software 2.0.0.3
- New ORTEC detector
FHT59C

- Moving filter monitor designed for low maintenance
- Very reliable mechanism
  - *EPA compliance monitor*
- Up to 1 year between filter changes
- Advance 1/day = 3 years to a new roll of filter paper
- Continuous monitoring using an alpha beta proportional detector
- Integrated into monitoring networks
FHT59E

- Noble gas monitor using two large area proportional detectors and anticoincidence
- 900 ml active volume chamber
- Lead shielding for use in higher background areas
  - Up to 10 mR/h
- Calibration for Kr-85 or Xe-133
- MDA’s 0.5 kBq/m³ and 1 kBq/m³
- Range is up to $3.7 \times 10^8$ Bq/m³
- Workplace or stack gas monitoring
- PC-based electronics
- Remote data access (networking)
FHT59SI

- Environmental monitoring
- Alpha and Beta aerosols
- 0.05/0.3 Bq/m³ to 0.5×10⁶ Bq/m³
- Moving filter mechanism
- Solid state alpha beta detector
- PC-based electronics
- 8 m³/h sample rate
- Data collection with remote capabilities
Communications

- RS232 or RS-485
- Ethernet communications
- Wireless communications
- GSM cell phones
- Satellite communications
Networking Software

- ViewPoint software
- Data Collection
- Data Archival
- Customized Displays
- Multiple communications pathways
- Easy Networking
- Works with many different types of instruments
- Configurable displays tailored to the facility
- Released in Q4 of 2004
Questions?

- Jeff Sawyer
- Product Sales Support Manager
- Phone: 800-274-4212 option 1 extension 1940
- Cellular: 505-660-4047
- E-Mail: jeff.sawyer@thermo.com
Automating Work Flow in an Air Monitoring Program with TRAC

“Totalized Retentive Air Collection”
Manual Air Sampling

• Conventional programs depend on manual data recording
• Manual data recording is:
  – Slow
  – Error prone
  and therefore is…

Expensive!
Manual Air Sampling Steps

Place air filter and record:
1. Location
2. Filter ID
3. Start time/date
4. Beginning air flow

Collect air filter and verify or record:
5. Location
6. Filter ID
7. Stop time/date
8. Ending air flow

Count air filter and transfer data:
9. Location ID
10. Filter ID
11. Start time/date
12. Stop time/date
13. Beginning air flow
14. Ending air flow
Manual Air Sampling

• **14 points to:**
  – *Introduce data errors*
  – *Use a lot of worker time*

• **Estimated time is:**
  10-15 minutes* per sample for manual data processing

*K-25 Project, Bechtel-Jacobs & SEC user estimates of time based on existing manual system procedures
“TRAC” Air Sampling

• With a TRAC system:
  – Place air filter
  – Collect air filter
  – Count air filter

Data is collected and transferred automatically

Protean Instrument Corporation  www.proteaninstrument.com
TRAC System

- **Totalized Retentive Air Collection** is:
  - *TRAC equipped air sampling station*
    - Fixed or Portable (*Wheeled or Desktop*)
  - *TRAC air filter carrier*
    - Uses your existing 2” sample media
  - *TRAC equipped counting system*
    - Automatic single detector, Manual multi-detector, Manual single detector
TRAC Components

• **Sampling head**
  – Holds TRAC carrier
  – Interfaces with TRAC controller
  – Can mount on flexible extension hose for remote positioning
  – Simple & fast “drop-in” loading of carrier
TRAC Components

• TRAC Carrier
  – Uses standard media
  – Stores collection parameters
  – Uses non-volatile memory
    • Rugged, environmentally sealed
  – Hard coded serial number is tamper resistant
TRAC Components

• TRAC Controller
  – Updates every few seconds
  – Calibrated mass flow sensor
  – Corrects air flow to STP
  – Can control pump
  – Corrects for filter loading
  – Unique ID per controller
  – Battery backed memory
TRAC Components

- TRAC Pump (THS)
  - Has flow controller
  - HEPA filter
  - Pump
  - Head extension
  - Remote head
  - Wheeled cabinet
TRAC Components

- **TRAC Controller**
  - Programmable for
    - Collected volume (L or F³)
    - Time
  - Auto resume on power fail
  - Writes to TRAC carrier
    - Start/Stop time & date
    - Pump ID
    - Totalized air volume
  - Retrofits to existing pumps

*Protean Instrument Corporation*

[Link to Protean Instrument Corporation website](www.proteaninstrument.com)
TRAC Components

- **TRAC Equipped Counting System**
  - Automatic or manual systems
  - TRAC reader transfers data from button memory
  - Systems have built in reports to use TRAC data

Protean Instrument Corporation  www.proteaninstrument.com
TRAC Components

• TRAC Calibration
  – Return to Protean
  or…
  – Use TRAC Calibrator
    • Contains high precision mass flow sensor
    • Calibrate systems as needed in-house
Benefits of TRAC

- **14 manual data steps are reduced to 0**
  - *No* chance for errors
  - *No* time spent manually transferring data
- **Data is more accurate**
  - Corrected for STP
  - Corrected for filter loading
- **Low cost**
  - Standard 2 inch filter media
  - Special software *not* required
  - Software license *not* required
More Benefits of TRAC

- Counting system option is rational
  - Low cost at ~$600 per system
  - Doesn’t interfere with normal system operation
  - Doesn’t change counting performance

- System is Scalable
  - Can be built from single pump to as many as required

- Does not require additional hardware
  - No expensive hand held readers
  - No expensive options on counting system

Protean Instrument Corporation  www.proteaninstrument.com
Is TRAC Worth It?

- **Manual system:**
  - Use these factors
    - \( L \) = Labor cost in \$/hour
    - \( F \) = Number of filters/year
    - \( T \) = Time for manual data transfer
      - Estimated 10 minutes/filter

\[
\text{Cost} = \frac{LFT}{60} = \text{Total} \ \$/\text{year}
\]

Protean Instrument Corporation       www.proteaninstrument.com
Is TRAC Worth It?

• **TRAC system:**
  – Use these factors
    • Manual cost = $F \times T \times L / 60 = M$
    • Automatic system is cost of pumps + TRAC sample heads + TRAC controllers = $A$
    • Payoff is $A / M$ in years

*NOTE: Cost of filter media, counting system(s) is constant for both methods*
Is TRAC Worth It?

- Somewhat hypothetical example:
  - 10 station system with 5 fixed and 5 mobile sample heads = ~ $35,000 acquisition cost*
  - Labor is $25/loaded hour
  - Sampling is 2 filters/day/station = 7300 samples/year
  - Cost is: $30,417/year
  - System is paid for in 1.15 years

*Assumes an counting system is already available – double cost & payoff time to add new TRAC compatible automatic ultra-low background system

Protean Instrument Corporation www.proteaninstrument.com
Long Term Cost Reduction

• Low cost media
• Low cost maintenance
  – No software upgrades or licenses
• Easy scaling
  – Start with 1 TRAC pump
• Low maintenance
  – Especially counting systems
• Reduced labor cost
In Development

- **TRAC “Lite”**
  - Lower cost multi-head sampling
  - No mass-flow sensor
  - No flow totalization
  - Records start/stop time & date on carrier
  - Single controller can run multiple heads
  - Designed for large in-house pumping systems
  - Uses in-house total flow calibrations
LRRI’s Capabilities to Test and Evaluate Radioactive and Biological Aerosol Monitors

Thomas D. Holmes
Lovelace Respiratory Research Institute (LRRI)
Albuquerque, NM
April, 2006
LRRI History

Lovelace Foundation for Medical Education and Research
• High altitude research for the military
• Mercury astronaut test program

Fission Product Inhalation Laboratory
• AEC contracts Lovelace to construct and operate a laboratory to study exposure to radiation and blast injury

Inhalation Toxicology Research Institute (ITRI)
• AEC expands contracts to include exposure to transuranic actinides
• AEC is succeeded by the DOE
• DOE expands contracts to include non-nuclear, energy related pollutants

Lovelace Respiratory Research Institute (LRRI)
• LRRI becomes a private corporation
LRRI Facilities 1960s
LRRI Facilities/Staff Today

- North Campus: ~120,000 sq. ft.
- South Campus: ~330,000 sq. ft.
- 70 PhD level scientists, 330 technicians and support staff
Aerosol Group Contact

Yung Sung Cheng, Ph.D.
Director, Aerosol & Respiratory Dosimetry Program

Lovelace Respiratory Research Institute
2425 Ridgecrest, SE
Albuquerque, NM 87108, USA
(TEL) 505-348-9410
(FAX) 505-348-8567
ycheng@lrri.org
Need for Radioactive and Biological Aerosol Sampling

Radioactive:
• Industrial Hygiene
• Detection of Nuclear Tests or Accidental Releases
• Environmental Regulations
• Homeland Security

Biological:
• Industrial Hygiene
• Homeland Security
Steps to Airborne Radionuclide and Biological Agent Detection

• Aspiration
• Collection
• Detection
• Analysis
Ideal Sampler

• Sample only Particles of Desired Size (e.g., 0.5 μm - 10 μm)

• Provide Representative Sample

• Performance Independent of:
  • wind speed
  • turbulence scale and intensity and
  • extraneous airborne matter (rain, snow, insects, debris, etc.)
Ideal Sampler (Cont’d)

• Zero False Alarm

• Real Time Results

• and much more (light weight, low power consumption, portable, etc.)
Wind Tunnel Evaluation

• Determine the Aspiration Efficiency of the sampler

• Determine sampler Collection Efficiency as a function of Wind Speed and Particle Size using test aerosols

• Simulants for Bioaerosol Samplers e.g., Bacillus Subtilus (BG)

• Identify the areas of particle losses
## LRRI Wind Tunnel Facilities

<table>
<thead>
<tr>
<th>Feature</th>
<th>North Facility</th>
<th>South Facility</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wind Speed</td>
<td>0.5 m/s - 7 m/s</td>
<td>0.5-m/s - 24 m/s</td>
</tr>
<tr>
<td>Test Section</td>
<td>12’ x 12’</td>
<td>2.5’ x 2.5’</td>
</tr>
<tr>
<td>(1’ dia. - higher wind speed)</td>
<td></td>
<td>(1’ dia.- higher wind speed)</td>
</tr>
<tr>
<td>Mixing Device</td>
<td>Air Blender</td>
<td>Stairmand Disc</td>
</tr>
<tr>
<td>Test Aerosol Used</td>
<td>Liquid/Solid Particles</td>
<td>Liquid/Solid Biological Agent</td>
</tr>
</tbody>
</table>
Wind Tunnel - North

Bell Mouth
Bolt Flange
Air Blender
Flow Straightener (see detail)
pt - A
HEPA Filter
Blower

Dimensions:
- 12.0
- 14.0
- 72.0
- 360.0
- 15.0
- 48.0
- 180.0
- 12.0
- 6.0
- 144.0
- 45.0
(Approx.)
Wind Tunnel - North

Test Section
Wind Tunnel - South
Wind Tunnel - South
Plutonium CAM Exposure Line

Pu-239 Exposure Glove Box
Plutonium CAM Exposure Line
Radionuclide Samplers Tested at LRRI

SabreBZM

Snow White
Bio-Samplers Tested at LRRI

XMX

ASAP-PM10

PSU-2
Analyses

• Gravimetric Analysis
• Fluorometric Analysis
• EpifluorocSENT Microscopy
• Electron Microscopy
• Growth Media Culture
• Flow Cytometry
• Various Chemical Analyses
Image Analysis
Performance Evaluation
Criteria for Various Samplers

Sampling Efficiency
• ≥ 50%

Homogeneity of Particle Collection

Air In-Leakage
• < 10%

Response Time
• Pu aerosol challenge

False Alarm Rate
• Radon background
Typical Sampling Results for an Alpha Continuous Air Monitor

![Graph showing efficiency (%) vs. particle size (µm AD) for Collection, Aspiration, and Wall Losses.](image)
Typical Sampling Efficiency Results for Alpha CAMs

![Graph showing sampling efficiency results for different samplers as a function of particle diameter.](image)
Homogeneity of Particle Collection from Image Analysis

Filter Scan

Particle Counts from Scan
Alpha CAM Alarm Response

Alarm at 80 sec
Typical Sampling Efficiency Results for Bio-Samplers

2 km/hr

8 km/hr
Bacillus Globigii (BG)
Bacillus Thuringiensis (BT)
Particle Sizing and Aerosol Concentration Equipment

- TSI Aerodynamic Particle Sizer
- API Aerosizer
- TSI DustTrak
- Microscopes for Particle Sizing
- Andersen Impactors
- Insitec PCSV (Particle Counter Sizer Velocity Meter)
- ETC…
Summary

• Performance evaluation is an important step for Radioactive and Bioaerosol Samplers

• LRRI has complete facilities, equipment, and expertise for testing various Aerosol Samplers

• Two aerosol wind tunnels can accommodate different size and multiple aerosol samplers
Contact Us

Lovelace Respiratory Research Institute
2425 Ridgecrest Dr. SE
Albuquerque, NM 87108
Phone: 505-348-9400
Fax: 505-348-8541
Web: www.lrri.org
Email: info@lrri.org
Lab Impex Systems Ltd

♦ Specialise in the design and manufacture of health physics and radiation protection systems

♦ Installed on-line monitoring systems
  ✓ Stand alone (aerosol, gas, dose, liquid)
  ✓ Building / Plant / Site / Regional networks
♦ Stack Sampling and Stack Flow Measurement

♦ Facilities in Rio Rancho, NM and in the United Kingdom
The SmartCAM
Aerosol Measurement: Technical ‘Challenges’

- A set of well defined challenges exist for all manufacturers of Continuous Air Monitors.
- Such challenges arise from inherent difficulties in aerosol measurement.
- These difficulties, which effect the quality of aerosol measurement, cannot be totally eradicated.

Often the way in which each CAM system handles each challenge, is the best criteria for clients to compare the worth of each system.
Rn-222 - Radon
(3.82d)
- 5.49 MeV alpha
  Po-218
(3.05 min)
- 6.0 MeV alpha
  Pb-214
(26.8 min)
- 0.67 MeV beta
  Bi-214
(19.7 min)
- 3.26 MeV beta
  Po-214
(164 uSec)
- 7.68 MeV alpha
  Pb-210
(22 yrs)
- 160 KeV beta
  Pb-206

Rn-220 - Thoron
(54.5 sec)
- 6.29 MeV alpha
  Po-216
(0.16 sec)
- 6.78 MeV alpha
  Pb-212
(10.6 hours)
- 0.58 MeV beta
  Bi-212
(60.5 min)
- 6.05 MeV alpha
  TI-208
(3.1 min)
- 2.25 MeV beta
  Po-212
(0.3 msec)
- 1.8 MeV beta
  Pb-208
(Stable)
- 8.78 MeV alpha
Rn-222 - Radon
(3.82d)
5.49 MeV alpha
Po-218
(3.05 min)
6.0 MeV alpha
Po-214
(164 uSec)
7.68 MeV alpha
Po-212
(0.3 msec)
8.78 MeV alpha
Pb-208
(Stable)
36%
6.05 MeV alpha
Bi-212
(60.5 min)
Pb-214
(26.8 min)
0.67 MeV beta
Bi-214
(19.7 min)
3.26 MeV beta
Po-214
(164 uSec)
7.68 MeV alpha
Pb-210
(22 yrs)
160 KeV beta
Pb-206
Rn-220 - Thoron
(54.5 sec)
6.29 MeV alpha
Po-216
(0.16 sec)
6.78 MeV alpha
Pb-212
(10.6 hours)
0.58 MeV beta
Bi-212
(60.5 min)
Tl-208
(3.1 min)
6.05 MeV alpha
36%
2.25 MeV beta
(0.3 msec)
Aerosol Measurement:
Challenge 1. (Alpha) – Radon Thoron Interference
Aerosol Measurement:

**Challenge 2. (Alpha) – Low Counting Rates**

- Assume concentration of 1 DAC of Pu-239 (2E-12 uCi/ml)
- In one hour (after sampling at 2 cfm), only 7 pCi on the filter
- Assume a counting efficiency of 25%, the count rate = 4 cpm (after 1 hour)

- Low counting rates mean CAM systems must use long counting times to gain statistically good results
Aerosol Measurement:  
Summary of ‘Challenges’

♦ The 1 DAC alpha action level: Low counting rate  
♦ Dust Loading and Filter-Sensor Air gap reduce energy resolution of a CAM system  
♦ Reduced Energy resolution = Greater Rn/Th interference in the Transuranic region

For optimum sensitivity CAM manufacturers must achieve sound Rn/Th compensation methods \textit{COMBINED} with sound calculation algorithms
SmartCAM Continuous Air Monitor
Alpha (and Beta) CAM

♦ Large Area, Color Touchscreen Display (5.25 x 4 inch)
♦ Full alpha spectral analysis with unique radon peak fitting algorithm
♦ Patented temperature and pressure spectrum stabilization
♦ Detachable head assembly for remote monitoring
♦ Stainless Steel Enclosure
♦ Optional external gamma dose-rate sensor
2) SmartCAM Filter

- Card mounted filter
- 1 inch active diameter
- Glass fibre (type GF/A) collection medium
- Optional membrane filter
- Quick filter exchange process
- Easy to handle and transport
- Optional bar coding of sample
3) **SmartCAM Display**

- Easy to use, easy to navigate touch screen display
- Continuous Display of:
  - Concentration (i.e. DAC) by Nuclide
  - Dose (i.e. DAC-h) by Nuclide
  - Sample Flow
  - Totalized Sample Flow
  - Sample Pressure
  - Sample Temperature
SmartCAM Display

3/16/2006
4:13:30 PM
Shift: 0

Pu239 4.63 DAC
0.71 DAC-h

U238 0.6 DAC
7.7 DAC-h

Dual Isotope Display
SmartCAM Display

Security Levels: User, Supervisor, Engineer, Calibrator
SmartCAM Display

Summary Screen: Instant review of all measured values
SmartCAM Display

Green = Peak Fit Line

Red = Raw Counts

Live Differential Spectrum Display
SmartCAM Display

Chart Screen: 4 hour rolling record of results as a percentage of alarm threshold
**SmartCAM Display**

**Event Log: Chronological List of Stored Events**

<table>
<thead>
<tr>
<th>Time</th>
<th>Status</th>
<th>Channel</th>
<th>Reading</th>
<th>Units</th>
<th>Alarm Limit</th>
<th>Units</th>
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<td>7.99052</td>
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<td></td>
</tr>
</tbody>
</table>
SmartCAM Display

Automated Efficiency and Energy Calibration Routines
SmartCAM Display

3/16/2006
4:22 PM

Simple Parameter Set-up
SmartCAM Head

♦ Rugged stainless steel construction
♦ Proven head design for maximum particulate collection efficiency
♦ Detachable for remote monitoring
♦ Filter Detector: High efficiency Ion implanted Planar Silicon (1 inch diameter)
♦ Identical ‘background’ detector for compensation of incident gamma photons (beta) or as a filter detector spare (alpha only)
SmartCAM Radon Rejection
Peak-Shape Fitting Definition

- Peak-Shape Fitting (PSF) uses a mathematical model to represent the shape of the complete spectrum (radon-thoron and transuranics)
- When the complete spectrum is modelled, each individual peak can be analysed and a net count result can be calculated for each peak

Why are we different:

- **We don’t fit the tail, we fit the full peak**
- **We measure temperature and pressure and automatically regulate the detector gain accordingly to ‘fix’ the spectrum in the same position at all times**
- **Our robust model allows ‘fast’ peak fitting – we don’t need to wait ‘as long’ as conventional systems for a well defined spectrum to accumulate before we compensate**
The SMART CAM……..Fits each peak

Note: Po-212 fit not shown
The SMART CAM........Fits each peak

Note: Po-212 fit not shown

Counts

Po-218 / Bi-212

Channel
Including the Transuranic(s)

Note: Po-212 fit not shown

Pu-239

Counts

Channel
The SMART CAM produces a mathematical model of the whole spectrum.

Note: Po-212 fit not shown.
This model is solved to give net counts for each transuranic

i.e. Pu239 = 27 counts
Successive Approximations

- Start fitting with an initial estimate for peak shape and peak position
- Solve for “best fit” by refining the estimates and comparing the square of individual channel errors.
- End when fit error stops improving.
Alpha Peak Fitting Model

♦ The model fits peak shape for each radon-thoron daughter and user selected artificial alpha(s)

♦ Least squared fit to is used to refine the peak fit

♦ The complete spectrum is then solved into individual peak areas.

♦ The net count rate in each peak areas is used to calculate DAC and DAC-h

♦ Dynamic Differential Peak Fitting. We clear the spectrum after each successfully spectrum fit. This means we are only using the latest data to fit the peak – this reduces the risk of old spectrum data masking current live events.

♦ SmartCAM plots raw counts and peak fit on the touchscreen
SmartCAM Outputs

- The SmartCAM supports stand-alone or network operation
- The SmartCAM offers a wide range of I/O’s
  - 4 x relay contacts
  - 3 x current outputs 4-20 mA
  - 1 x RS-485 port
  - 1 x RS-232 port
  - 1 x Ethernet (for Radnet or Windows TCP/IP protocols)
  - (Optional) 1 x USB for bi-directional transfer of data to/from a mass storage device
SmartCAM Flexibility

Measurement Head – Fixed or Detached

External vacuum pump or vacuum main connection

Optional gamma sensor for dose rate measurement
Other Capabilities

Gamma Monitors

Liquid Effluent

Tritium

.............Plus Noble Gas, Iodine, Stack Monitors and Process Monitors

Network Software
SmartCAM

Revolutionizing Aerosol Monitoring

♦ Card Mounted Filter Collection Medium
  *Ease of Handling, Simple Filter Identification,*
♦ Continuous Flow Rate Measurement (Actual LPM)
  *Increased Accuracy of Result Data*
♦ Stainless Steel Air Inlet
  *High Efficiency Sampling (Satisfies ALARA principle)*
♦ Full peak fitting radon compensation
  *Lower risk of false alarms*
♦ Optional Gamma Dose Rate Sensor
  *Cost saving, multi-application*
SmartCAM
Revolutionizing Aerosol Monitoring

- Differential Spectrum Analysis
  *Speed of Response*
- Air pressure and temperature measurement
  *True actual LPM reporting of sample flow rate*
  *Stabilizes spectrum and removes problems associated with spectrum shift*
- Detachable Sample Inlet Head
  *Flexible*
- Moving Filter Mechanism
  *Cost saving*
SmartCAM - What’s next?

Future Enhancements
♦ Desk Top Version
♦ Automatic Filter Exchange
♦ ............