Using Fluid Transfer to Concentrate Heavy Noble Gases for High Sensitivity Long-Term Monitoring and Monitoring Air

J.D. Valentine, D.O. Stuenkel, and W.R. Russ, University of Cincinnati
K.C. Gross, Argonne National Laboratory

Fluid Transfer Concentration

Detection Schemes

Abstract

A University of Cincinnati/Argonne National Laboratory (UC/ANL) team is developing novel high sensitivity heavy noble gas (krypton, xenon, and radon) detectors. A new technique for concentrating the heavy noble gases from air is being integrated with state-of-the-art radiation detector technology and pulse processing techniques. It is anticipated that these detectors can be configured such that ambient heavy noble gas concentration can be monitored continuously, recorded in real-time, and in situ. This real-time data acquisition coupled with the ability to measure the beta particles and gamma rays emitted by krypton and xenon in coincidence mode will result in an enhanced ability both to use spectral information to detect and identify the different noble gas isotopes and to discriminate against all other signals. Such an integrated concentration and detection system has the potential to provide low-cost and low-complexity detectors which would be ideally suited for long-term monitoring and fieldable air monitors.

DOE Needs Addressed

- Long-Term Monitoring
  - Spent fuel waste and remediation sites
  - TRU waste and remediation sites
- Air Monitoring
  - Distinguishing background radon activity from other airborne alpha emissions

Absorption Tower

- Working fluid: corn oil
- Cross-current flow packed bed type absorption tower
  - Oil flows down
  - Air flows up
- Packed bed consists of 0.6 cm cut polyethylene tubing
- Prototype height limited to 50 cm by fume hood

CAUTION
RADIOACTIVE
MATERIAL

Degassing Techniques

- Heating - effective, somewhat inefficient
- Mechanical Agitation - ineffective
  - Magnetic stirrer
  - Ultrasound
  - Spraying
- Vacuum - effective, slow
- Thin Film - effective, slow
- Combinations
  - Ultrasound/Vacuum - effective, faster
  - Ultrasound/Thin Film/Vacuum - most effective and efficient to date
  - Spraying/Thin Film/Vacuum - currently being studied

On-Going Research

- Characterization and optimization of absorption process
- Characterization and optimization of degassing processes
- Evaluation and testing of detection schemes
- Modeling of integrated system to guide optimization of final design

Preliminary Results

- Oil Capacity:
  - Rn-222: 1,500 pCi/l
  - Xe-133: 2,500 pCi/l
- Concentration Factors:
  - Rn: 13.4
  - Xe: 2.5
- Absorption Efficiency
  - Rn: > 90%
  - Xe: 50%
- Degas Efficiency
  - Rn: 100%
  - Xe: 67%
- Beta/Gamma Coincidence reduces background by 2 to 4 orders of magnitude

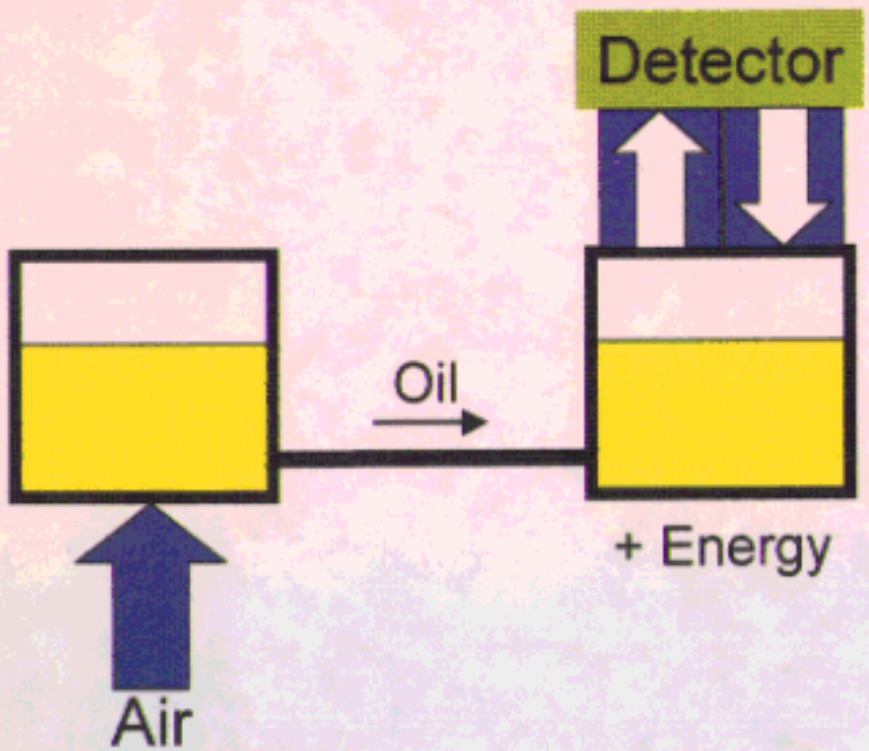
Pulse Processing Techniques

- Alpha/Beta Discrimination
  - Pulse Shape Analysis
  - Pulse Height Analysis
- Beta/Gamma-Ray Coincidence
- Delayed Coincidence

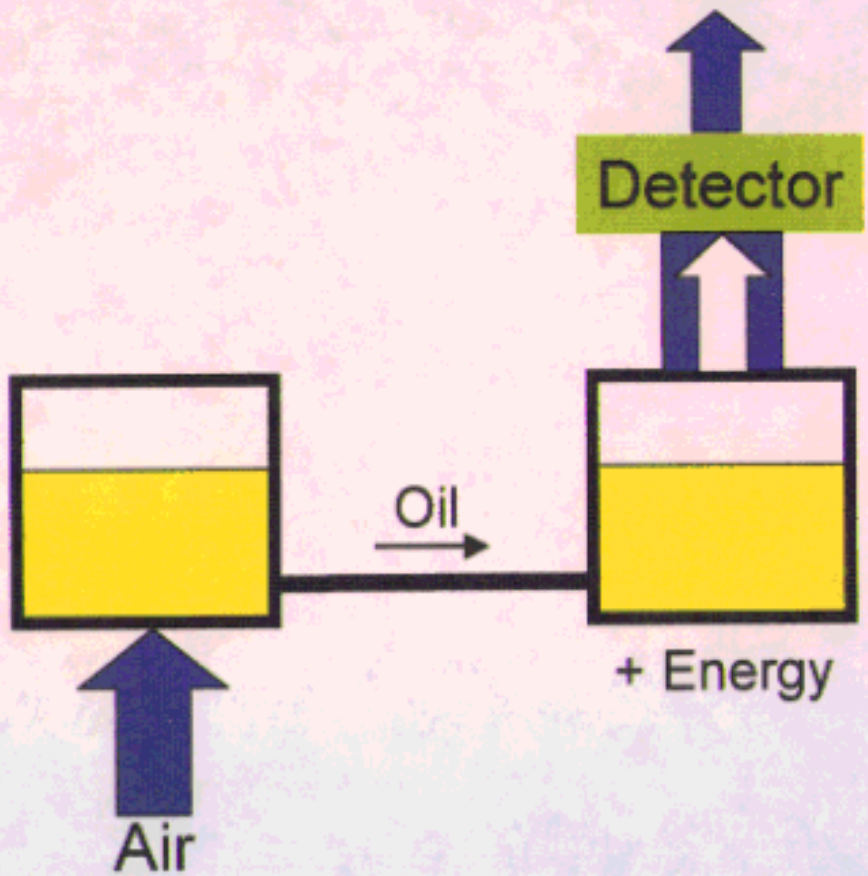
Detectors

- Alpha and/or Beta Detectors
  - Gas Proportional Detectors
  - Plastic Scintillators
  - Liquid Scintillators
  - ZnS
  - CsI(Tl)
  - Silicon PIPS
- X-Ray/Gamma-Ray Detectors
  - NaI(Tl)
  - HPGe
  - CdZnTe

Long-Term Monitoring

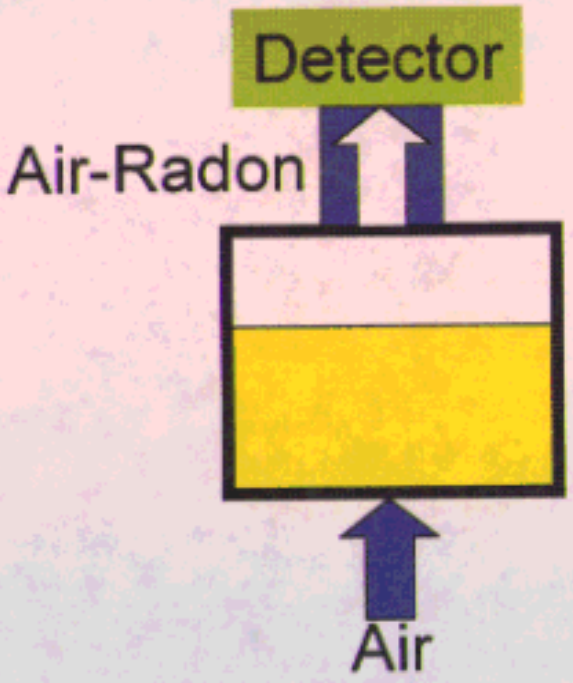


High Sensitivity (Kr, Xe)
(recirculation or hold-up)

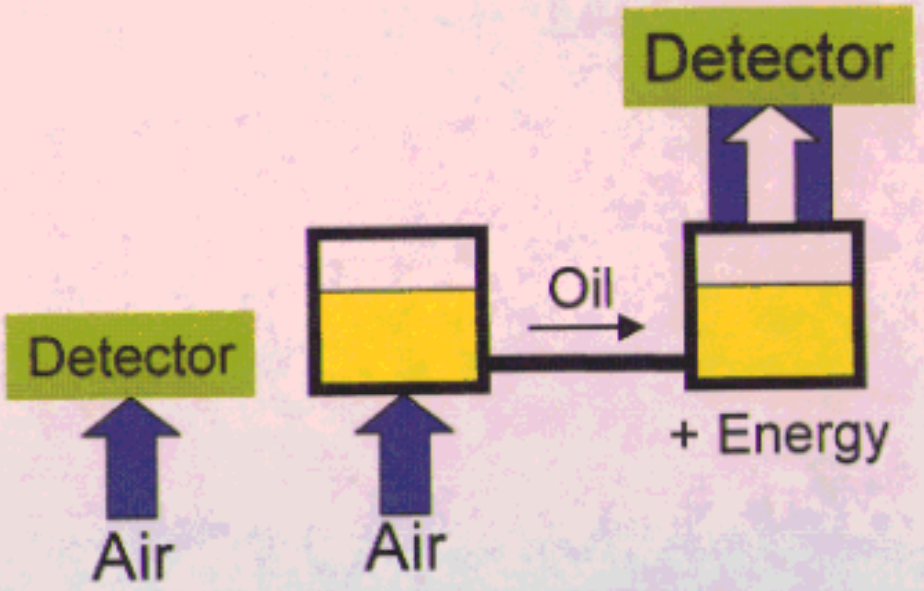


Moderate Sensitivity (Rn)
(once-through)

Air Monitoring

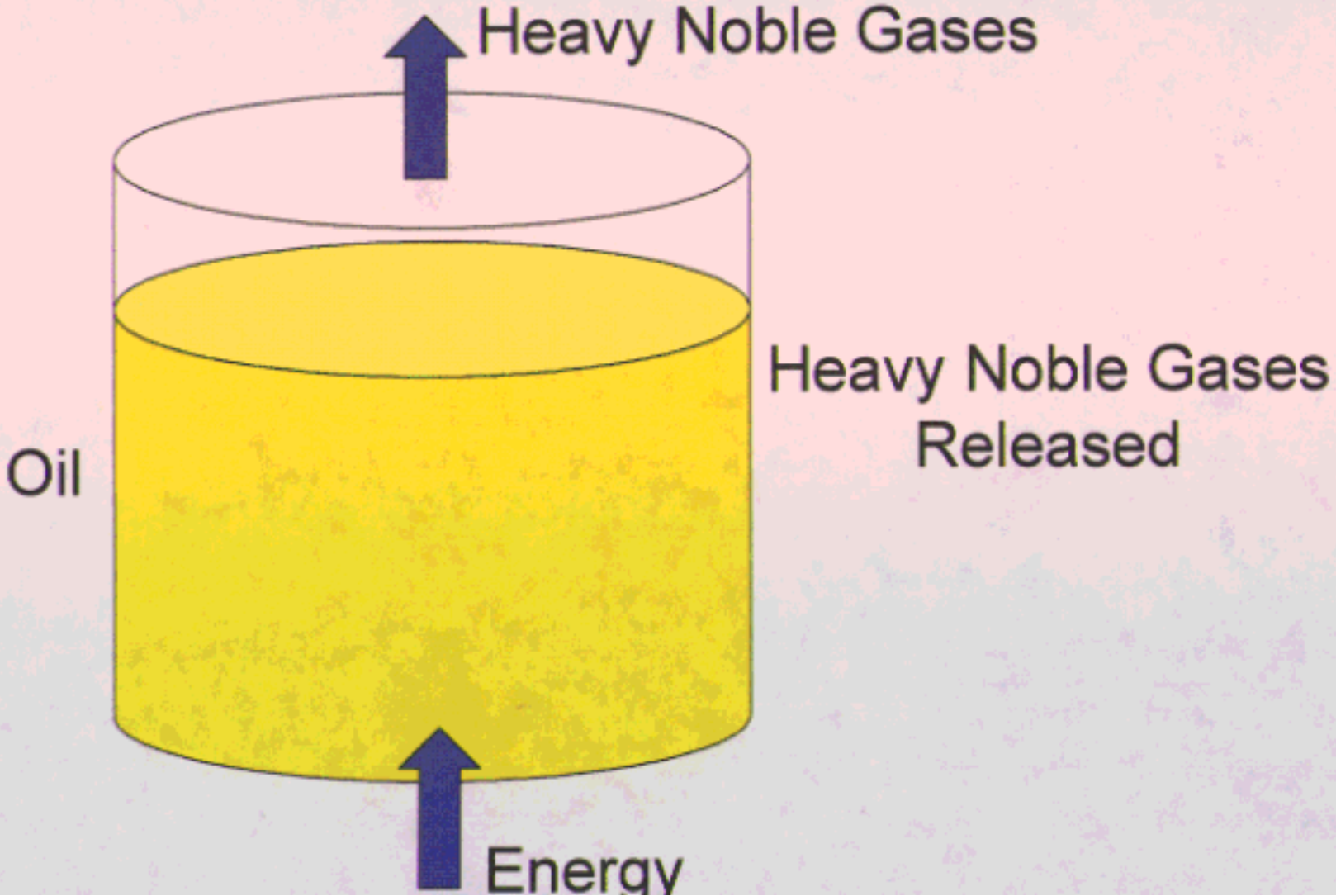


Radon Removal

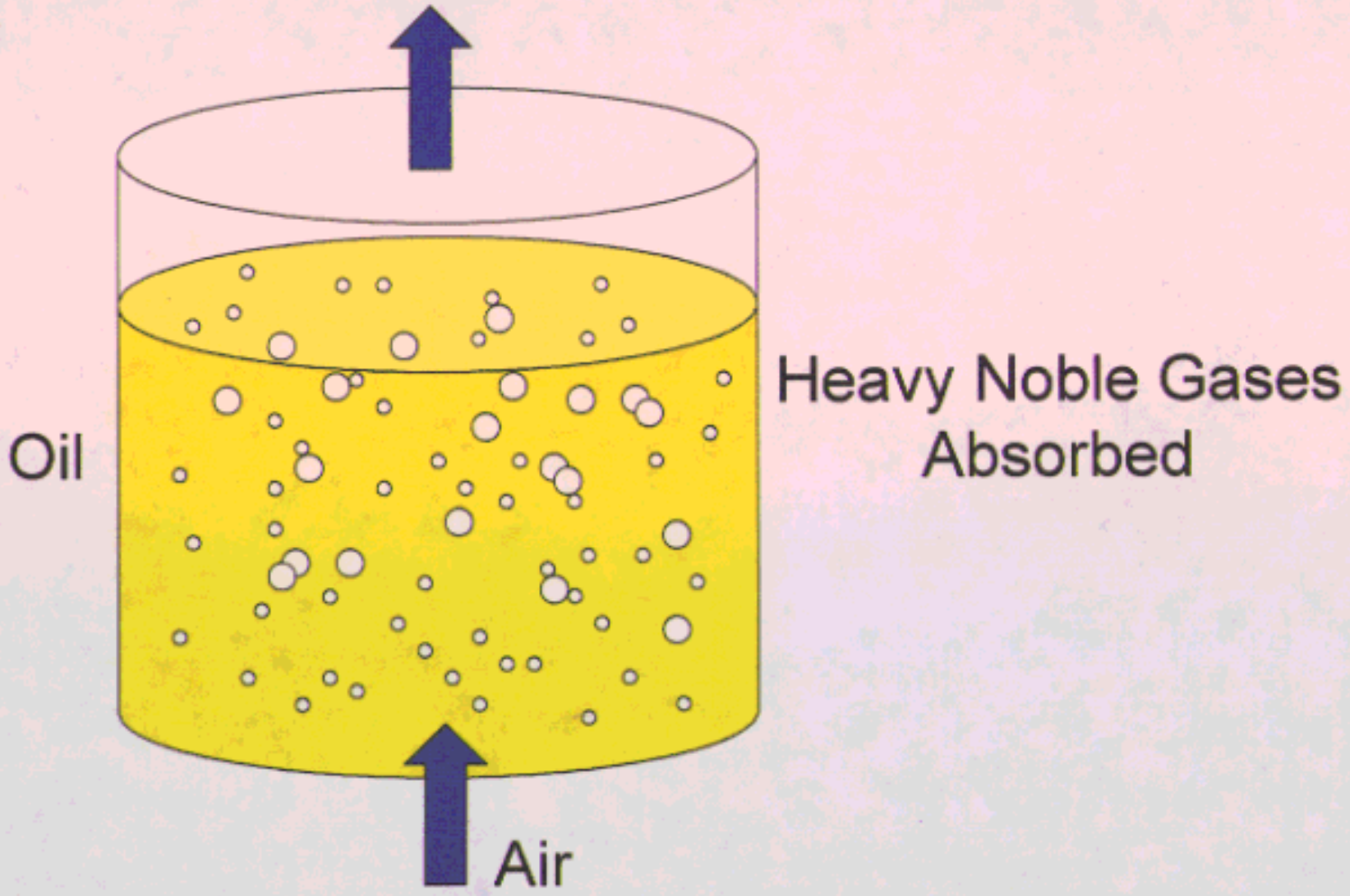
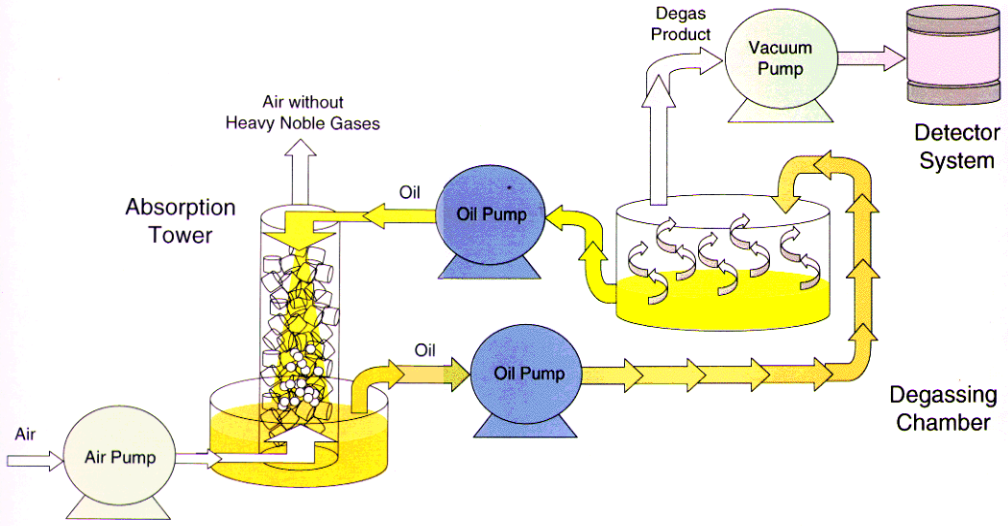


Compensation

Degassing



Absorption



Integrated System