Ramifications of New DAC Values on CAM Sensitivities

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Alan Justus

Health Physics Measurement Group (RP-2)

Radiation Instrumentation and Calibration Team (RIC)

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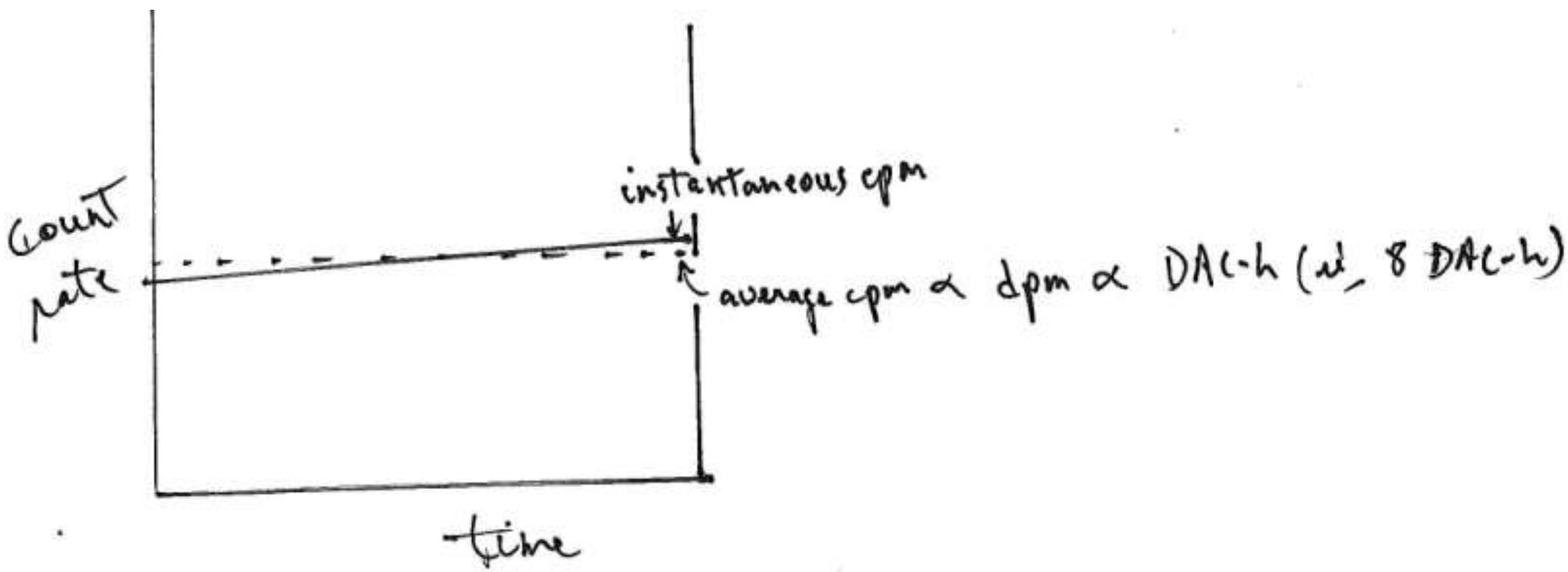
Outline of Presentation:

- Meaning of CAM instrument determined count rates
- Examples for steady-state and puff scenarios.
- Effect of alarm levels on detectable activity levels.
- Conversion factors between DAC-h and dpm activities on the filter.
- Summary of the ramifications.
- Discussion of an 8 DAC-h alarm level.

CAM alarms ultimately act on an average count rate

- **CAM instrument does not measure instantaneous count (or disintegration) rates.**
- **CAM instrument determines a count rate from counts integrated over a finite time interval.**
- **For the time interval less than or equal to about 1 minute, called the Acute or Fast rate.**
- **For time interval greater than or equal to about 10 minutes, called the Chronic or Slow rate.**
- **Both intervals should 'slide' or 'march' or 'roll' forward in time, being reevaluated in step sizes of 10% or less, i.e., at least every 6 sec for a 60-sec Fast interval and every 1 minute for a 10-min Slow interval.**
- **False alarm probabilities are only assigned to totally independent intervals. Use of sliding windows does not increase false alarm rate.**

Example average count rate for a slow steady-state release



Some characteristics of a puff release - Semi-log Plots of Clearances from (1) Equivalent Breathing Zone of Most Affected Workers and (2) the General Room

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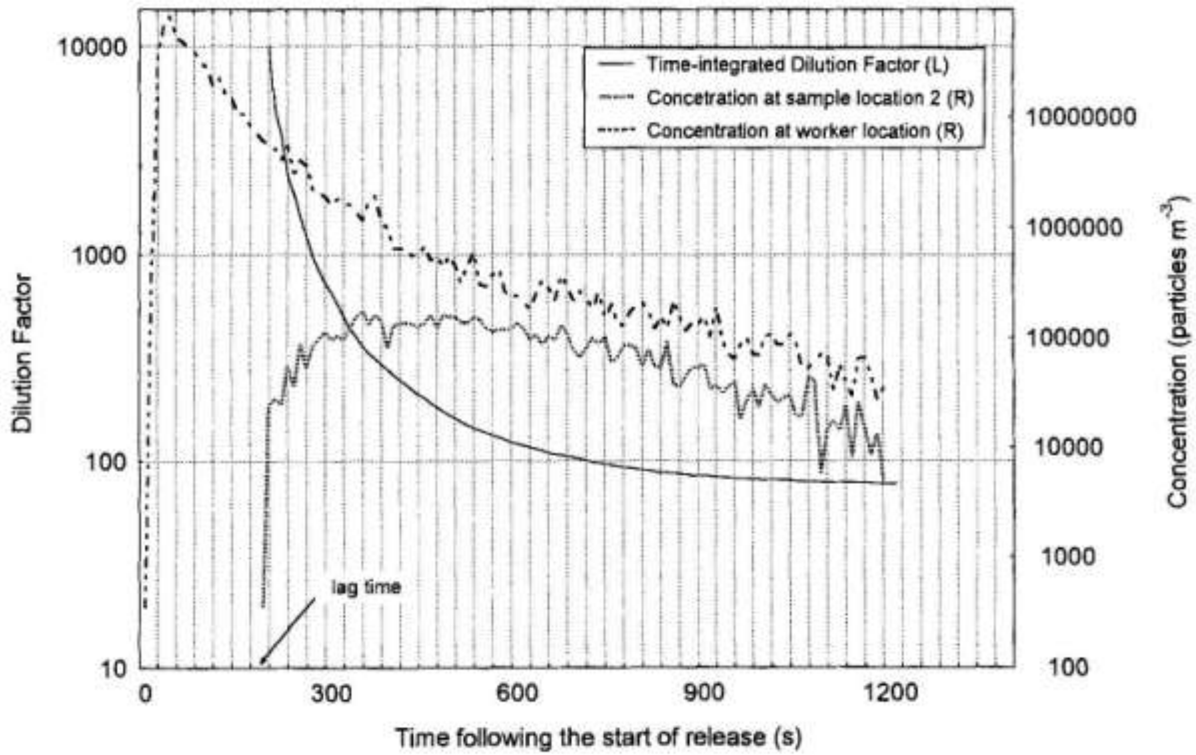


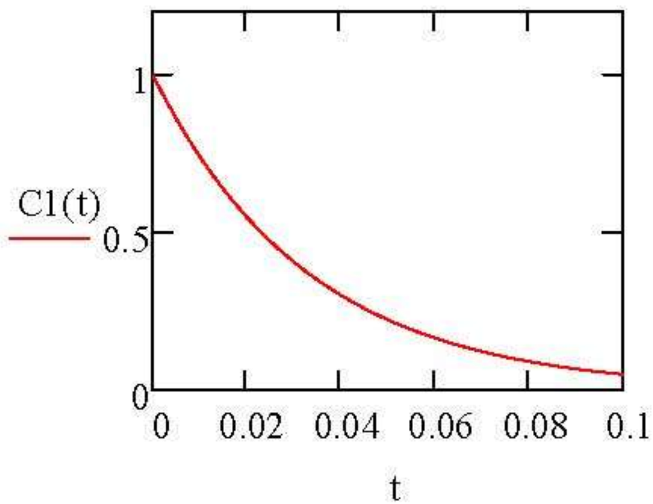
Fig. 7. Concentrations for worker and sample locations and the corresponding time-integrated dilution factors over time for a release in room 420.

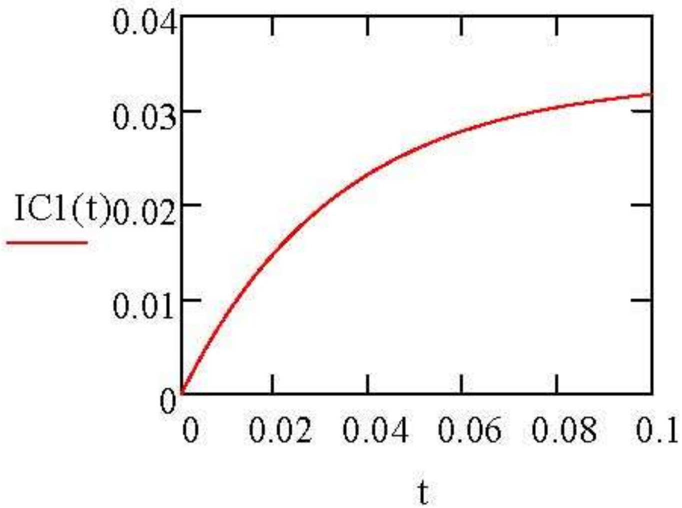
Characteristics of puff release (cont.)

$$\lambda 1 := 30$$

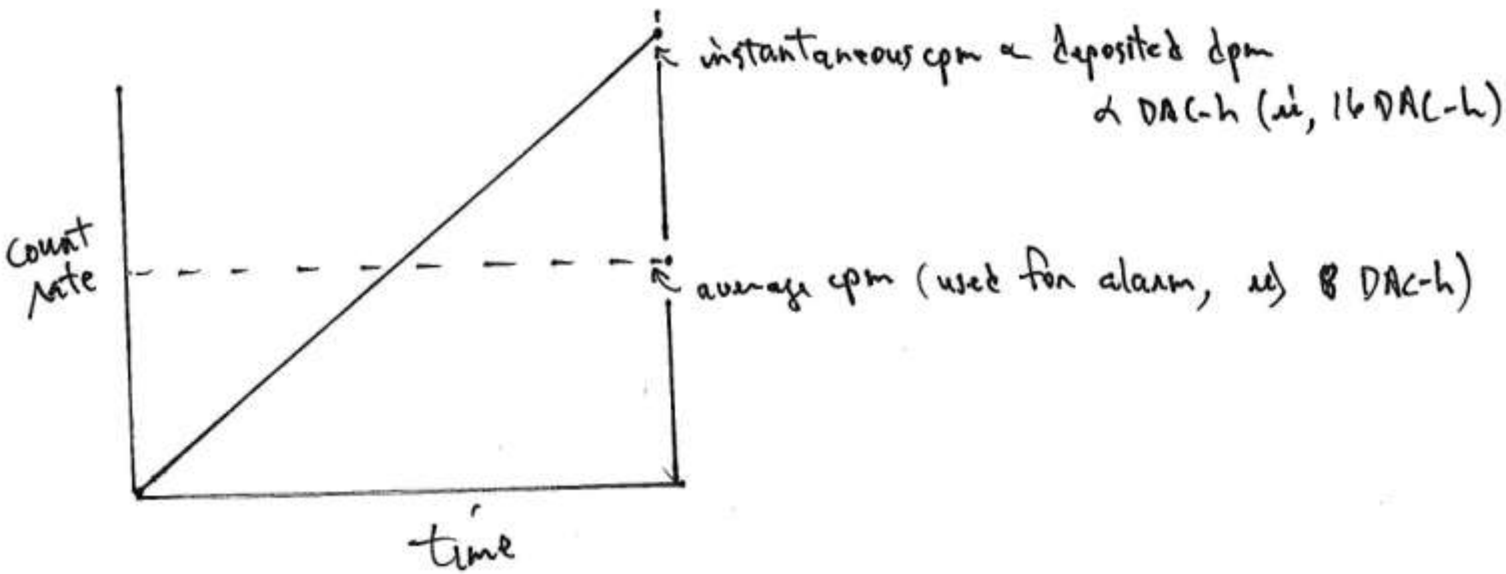
$$C1(t) := e^{-\lambda 1 \cdot t}$$

$$IC1(t) := \frac{\left(1 - e^{-\lambda 1 \cdot t}\right)}{\lambda 1}$$



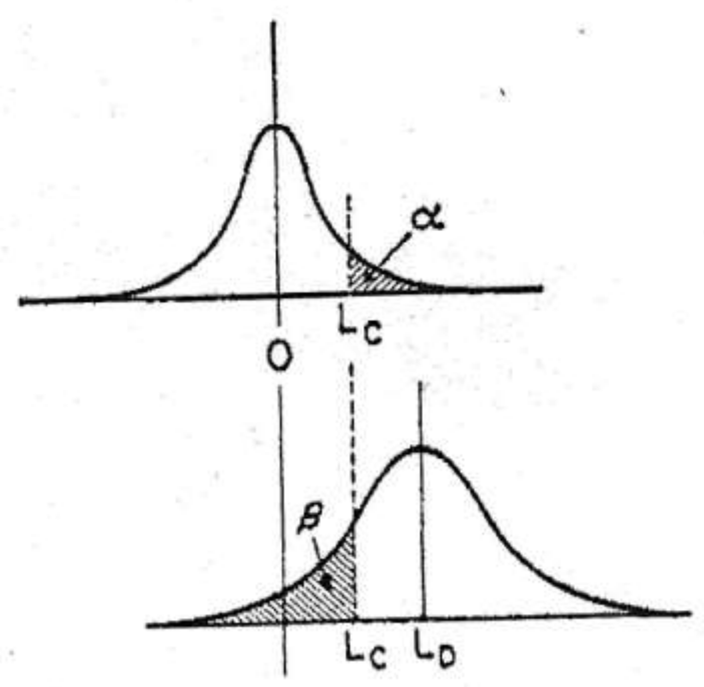


Example average count rate for a puff release (near time = 0)



- Note that the instantaneous count rate at the end on the count window can be up to 2 times the average count rate returned by the CAM for that window.

Meaning of alarm level (L_C) w.r.t. sensitivity (L_D)



Example MDAs for a steady-state release scenario (note: based on old DAC value)

Sensitivity summary for an Alpha7L with a CAM false alarm rate based on a statistical $\alpha = 1 \times 10^{-9}$ per independent decision.

		MDA[a] (in DAC-h) at Acceptable Alarm Setpoint (in σ) at the Assumed Radon Concentration[b]		
Integration Time Period	Number of independent decisions per 8766 hours	0.2 $pCi \cdot L^{-1}$ (7.4 $Bq \cdot m^{-3}$)	1 $pCi \cdot L^{-1}$ (37 $Bq \cdot m^{-3}$)	4 $pCi \cdot L^{-1}$ (148 $Bq \cdot m^{-3}$)
60 sec	5.3×10^{5}	8.4-12 (4.11σ)	14-19 (4.32σ)	25-32 (4.47σ)
6 min	8.8×10^{4}	2.5-3.4 (4.35σ)	4.9-6.4 (4.48σ)	9.3-12 (4.63σ)
36 min	1.5×10^{4}	0.88-1.1 (4.47σ)	1.8-2.4 (4.55σ)	3.5-4.6 (4.51σ)

[a] Presented as a range, from that at the 50% to the 95% detection probability for the steady-state (i.e., check source or hot-particle) release case. MDA values will be larger by up to a factor of 2 for the puff release case.

[b] Presumes 30-min age of air with regards to equilibrium activity of ^{218}Po, a flow rate of 42 lpm, and a counting efficiency of 0.25 cts/dis. Ignored is the initial development of the equilibrium activities at the beginning of each week's new filter

- Note that the MDA at a 95% detection probability can be up to 1.5 times the MDA at a 50% detection probability (which is essentially at the L_C alarm level).

Conversion of Activity to DAC-h

- **The activity (i.e., dpm) on the filter media (or a wide area check source, as wide as the active area) can readily be converted to a DAC-h value as long as the flow rate, F (i.e., lpm), and the DAC value (i.e., dpm/l) are known.**

$$\text{Exposure (DAC-h)} = A(\text{dpm}) * 20/F * [\ 2000\ \text{DAC-h} / 1\ \text{ALI(dpm)}\ ]$$

- **The 20/F term is to renormalize the activity sampled on the filter media to that which a standard man would have 'sampled'.**
- **The term in brackets is the unit conversion factor. Note that since 1 ALI(dpm) = DAC(dpm/l) * 2.4×10^6 l, where 20 lpm * 2000 h * 60 min/h is 2.4×10^6 l, the equation becomes:**

$$\text{Exposure (DAC-h)} = A(\text{dpm}) * 20/F * [\ 2000\ \text{DAC-h} / \text{DAC(dpm/l)}*2.4\times10^6\ \text{l}\ ]$$

Conversion for Old DAC values

- The most conservative Old Pu-239 DAC value, inhalation class W, was 2×10^{-12} uCi/ml or 0.00444 dpm/l. The conversion factor then became:

  K(DAC-h / dpm) = 3.75375 / F(lpm)

- For the Thermo Alpha 7L at 42 lpm, this became 0.089375 DAC-h/dpm, or 11.19 dpm/DAC-h. Therefore, 8 DAC-h equated to 89.5 dpm and, through a 0.24 cts/dis counting efficiency, **only 22 cpm**.
- For the Canberra Alpha Sentry 1700 at 56 lpm, this became 0.067031 DAC-h/dpm, or 14.92 dpm/DAC-h. Therefore, 8 DAC-h equated to 119 dpm and, through a 0.34 cts/dis counting efficiency, **only 41 cpm**.

Conversion for New DAC values

- The most conservative New Pu-239 DAC value, inhalation type M, is 5×10^{-12} uCi/ml or 0.0111 dpm/l. **This is 2.5 times the previous value**. The conversion factor now becomes:

  K(DAC-h / dpm) = 1.5015 / F(lpm)

- For the Thermo Alpha 7L at 42 lpm, this is now 0.03575 DAC-h/dpm, or 27.97 dpm/DAC-h. Therefore, 8 DAC-h equates to 223.8 dpm and, through a 0.24 cts/dis counting efficiency, **now 54 cpm**.
- For the Canberra Alpha Sentry 1700 at 56 lpm, this is now 0.02681 DAC-h/dpm, or 37.3 dpm/DAC-h. Therefore, 8 DAC-h equates to 298.4 dpm and, through a 0.34 cts/dis counting efficiency, **now 101 cpm**.
- **Note that, not surprisingly, both count rates are 2.5 times larger than previous.**

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Summary of ramifications

- **Some user-entered alarm (L_C) levels in DAC-h units are unchanged (i.e., 8 DAC-h for the Alpha Sentry chronic window and a factor of 2.5 desensitization for its acute window).**
- **However, the alarm levels in count rate units are 2.5 times larger than previously achievable due to the use of new DAC values.**
- **Note that any user-entered alarm (L_C) level represents an underestimate of the actual (MDA) sensitivity by up to a factor of 3 (i.e., x2 due to average count rate in a puff release scenario plus x1.5 due to L_D considerations at high detection probabilities). This can equate to sensitivities at the CAM heads ranging from dozens of DAC-h for slow windows to literally 100's of DAC-h for fast windows. (Note that ventilation-driven dilution factors are not included here; actual sensitivities at the nose can be substantially worse.)**

8 DAC-h?

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PLUTONIUM ALPHA AIR MONITOR USING A SOLID STATE DETECTOR*

W. A. PHILLIPS AND C. L. LINDEKEN
Lawrence Radiation Laboratory, University of California, Livermore, California

(*Received* 23 *May* 1962; *in revised form* 16 *August* 1962)

Abstract—A continuously indicating plutonium alpha air monitor using a *p–n* junction silicon detector and single-channel pulse-height analyzer is described. The resolution of the system excludes 98 per cent of the radon daughter alpha activity. One MPC of $plutonium^{239}$ can easily be seen within 8 hr of sampling.

8 DAC-h?

- **ANSI N42.18-1974 (R1980; formerly N13.10-1974), Specification and performance of on-site instrumentation for continuously monitoring radioactivity in effluents**:

  5.4.1.1 Instruments designed to continuously monitor radioactivity in gaseous effluent streams shall have a minimum level of detectability for … as given in Table 1…

  Table 1: ^{239}Pu - 2x10^{-12} uCi/ml w/ footnotes: (2) This table assumes continuous monitoring with the levels cited measurable at the 95 percent confidence level within a 4 hour period. It represents what is reasonably obtainable consistent with state-of-the-art measurement. (3) These values represent current minimum standards. Improved sensitivities are always encouraged and should be used when improved state-of-the-art and commercial availability are realized.

- **ANSI N317-1980, Performance criteria for instrumentation used for inplant plutonium monitoring:**

  5.3.1(1) The minimum detection level shall be 1 MPC of ^{239}Pu in 8 h (8 MPC hours) in the presence of nominal amounts of naturally occurring alpha emitters such as radon and thoron and their daughters. (This requirement is applicable to MPC values as of the date of this standard.)

8 DAC-h?

- **10CFR835.403(b), 09/30/2008**: Real-time monitoring shall be performed as necessary to detect and provide warning of airborne radioactivity concentrations that warrant immediate action to terminate inhalation of airborne radioactive material.
- **DOE G 441.1-1C, 05/19/2008**:

  10.2.2 ...real-time air monitoring should be used…where unexpected increases…could result in an exposure to an individual exceeding 40 DAC-h in one week.

  10.3 …together with the need for a rapid response to an unplanned release, means that optimal placement is critical. The technical basis for … placement should be documented.

  10.5.1 …should be capable of measuring 1 DAC when averaged over 8 hours (8 DAC-hours) under laboratory conditions. ***Alarm set points … should be set at the lowest practical level so as to accurately indicate loss of containment or the need for corrective action without causing a significant number of false alarms.*** When monitoring for alpha emitters shows high radon and thoron concentrations, an alarm set point of up to 24 DAC-hours may be acceptable. In all cases, the actual alarm set points established for each unit and the technical basis for the alarm set points should be documented.

  10.8.0 A document should be developed that provides the technical basis for selecting, placing, and operating air sampling and real-time air monitoring equipment. The document should include information such as …

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- **DOE-STD-1098-99, R12/2004**:

  555.3 ...to provide early warning to individuals of events that could lead to substantial unplanned exposures...as necessary to detect and provide warning …that warrant immediate action to terminate inhalation…

  555.5 …should be capable of measuring 1 DAC when averaged over 8 hours (8 DAC-hours) under laboratory conditions.

  555.7 A technical basis document should be developed for the airborne radioactivity monitoring program. The technical basis document should provide the basis for air monitor selection, placement, and operation.

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