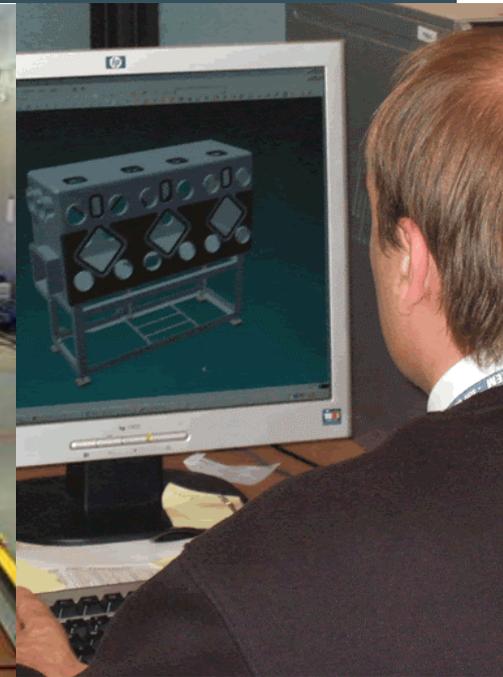


Tritium (H3) Good Practice Guide



Tritium monitor GPG

- **New Good Practice Guide (GPG)
for the Calibration of Tritium in
Air monitors**
 - **John Simpson**
 - **RWE NUKEM Ltd**

The Working Group

- **Working Group**
- Trevor Birkett AWE Aldermaston
- Peter Burgess National Physical Laboratory
- Julian Dean National Physical Laboratory
- John Simpson NUKEM Ltd
- Hilary Phillips National Physical Laboratory

The Writing Group

- **Writing Group**
- Trevor Birkett
AWE Aldermaston
- Peter Burgess
National Physical Laboratory
- Julian Dean
National Physical Laboratory
- John Simpson
NUKEM Ltd
- Hilary Phillips
National Physical Laboratory

Why this GPG

- Tritium is difficult to measure
- Tritium monitors are difficult to calibrate using tritium
- Therefore Tritium in Air Monitors (TAM) were not included in GPG82, the guide for 'in-air monitors.

Why do we need a guide

- very few facilities in the UK capable of delivering traceable quantities of tritium gas to TAM monitors and no facilities are available that can test the most common types of TAM across the full instrument range using tritium.
- tritium gas can plate out in the measurement chamber and the effect can be irreversible, and as most instruments are in place to monitor tritium levels close to background, undesirable

The Index

- **The Examination and Testing of Equipment for Monitoring Tritium in the Workplace**
- **Introduction**
- **Testing Regime**
 - Type Tests eg IEC 60761 (2002)
 - Tests Before First Use (TBFU)
 - Periodic Tests
 - Function Check
 - Retest after repair/adjustment
 - Analysis of test results
- **Instruments**
 - Measurement displays cps, $\mu\text{Ci}\cdot\text{m}^{-3}$, $\text{KBq}\cdot\text{m}^{-3}$, DAC, DAC.h etc

The Index 2

- **Specific tests on the air circuits of installed Tritium in air monitors**
 - Parameter check
 - Pump Test
 - Flow rate accuracy
 - Leakage
 - Fault Alarm Check
 - Low Flow, low battery where applicable
- **Specific tests on the radiation detection assembly for portable TAM**
 - Cancelling gamma compensation
 - Zero Check
 - Alarm Test
 - Linearity of response to activity

Index 3

- **Facilities and Traceability**
 - Workplace monitors
- **Certification of Tests**
 - Calibration Laboratory
 - Workplace testing
 - Test Label
- **Quantities and Units**
- **References**
- **Tables**
- Table 1 Summary of Tests Before First Use (TBFU)
- Table 2 Tests required for tritium monitors
- Table 3 Further Tests

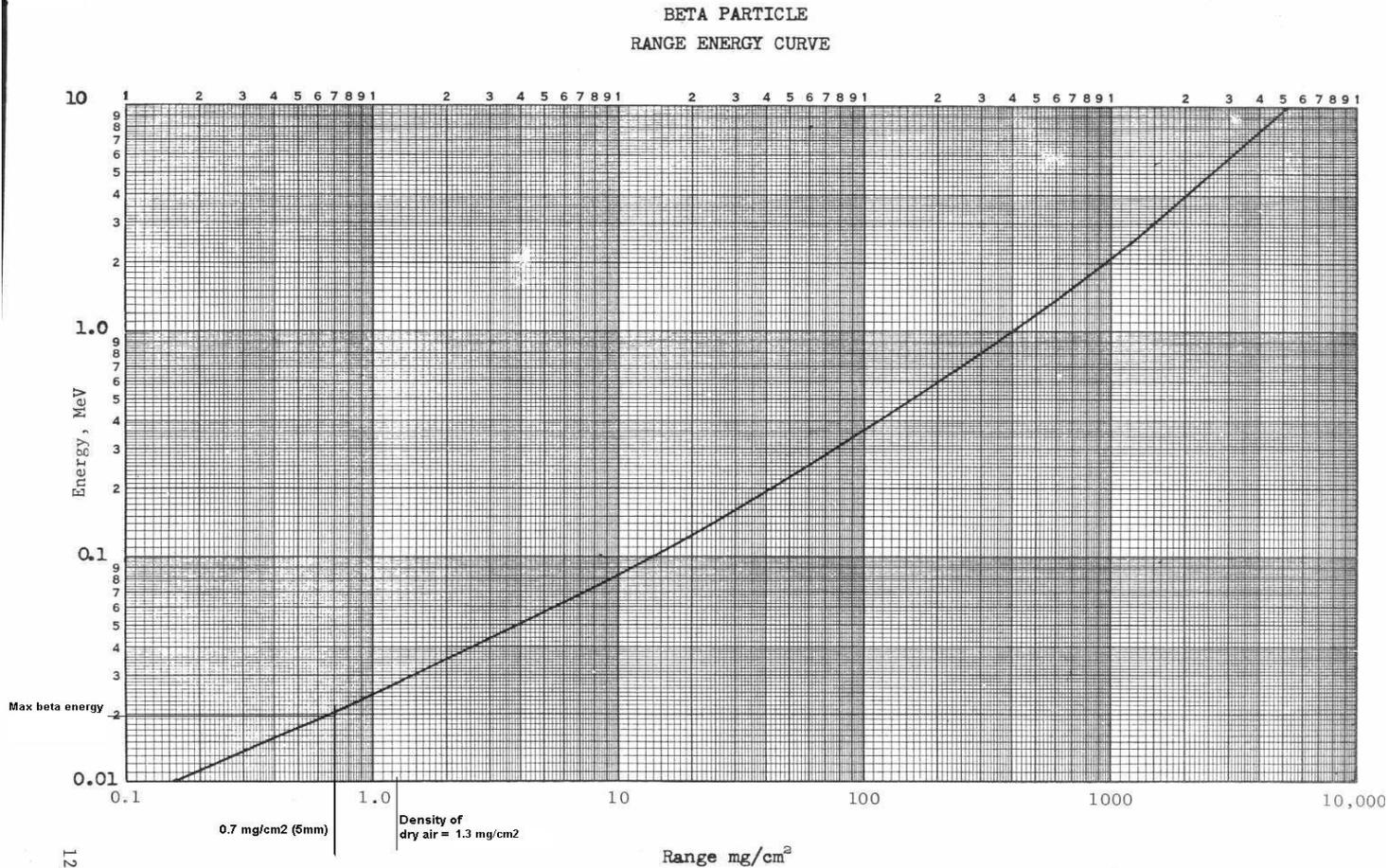
Index 4

- **Appendix 1** **Use of gamma dose rates to calibrate TAM monitors**
- Table A1 Tritium activity v gamma dose rate results
- Figure A1 Gamma results Indicated/True Overhoff 1400
- Figure A2 Tritium results Indicated/True Overhoff 1400
- Figure A3 Combined Tritium/Gamma results
- **Glossary**

Why is Tritium difficult to monitor

- Tritium
- 12.28 year half life. Single beta emitter, 100%, Beta max = 18.6 keV, beta mean = 5.7 keV
- No other emissions to latch onto such as X or gamma.

Range of H³ betas in air.



Air monitoring 2

- W value for air = 33 eV per collision, mean beta energy = 5700 eV
- No. of ion pairs produced = $5700/33 = 173$.
- Charge on electron = 1.6×10^{-19} C. $\therefore 1\text{Bq} = 2.77 \times 10^{-17}\text{C}$
- $\therefore 1\text{MBq.m}^{-3} \cong 2.77 \times 10^{-11}$ A
- For a 400 cc chamber the current will be $1.1 \times 10^{-14}\text{A}$
- Not a lot! The larger the chamber the better.

Measurement Range of Tritium monitors

- Overhoff 1400 Full scale = 370 MBq.m^{-3} , (10 mCi.m^{-3})
- Scintrex 309A Full scale = 7400 MBq.m^{-3} (200 mCi.m^{-3})
- Typical H^3 concentration available in bottles $\approx 200 \text{ MBq.m}^{-3}$
- Traceable overload test and linearity across full range is not possible. Hence Compliance with GPG14 not possible using H^3 or HTO.
- Strong possibility of contaminating instrument ion chamber!

Krypton 85

- OK, why not use another radioactive gas?
- E.g. ^{85}Kr ; noble gas, chemically inert, similar half-life.
- But: Beta (mean) = 251keV, 50 times the ^3H mean.
- Hence path length in the chamber is 50 times greater, introducing chamber wall effects, and this is difficult to take into account
- Plus still left with all the problems of using Radioactive materials

Calibration method using gamma radiation

- Alternatively: use a gamma calibration facility with sealed sources and traceable dose rates. No contamination to worry about and an equivalence of:

$$1 \text{ MBq.m}^{-3} \cong 3 \text{ } \mu\text{Sv.h}^{-1}$$

can be used.

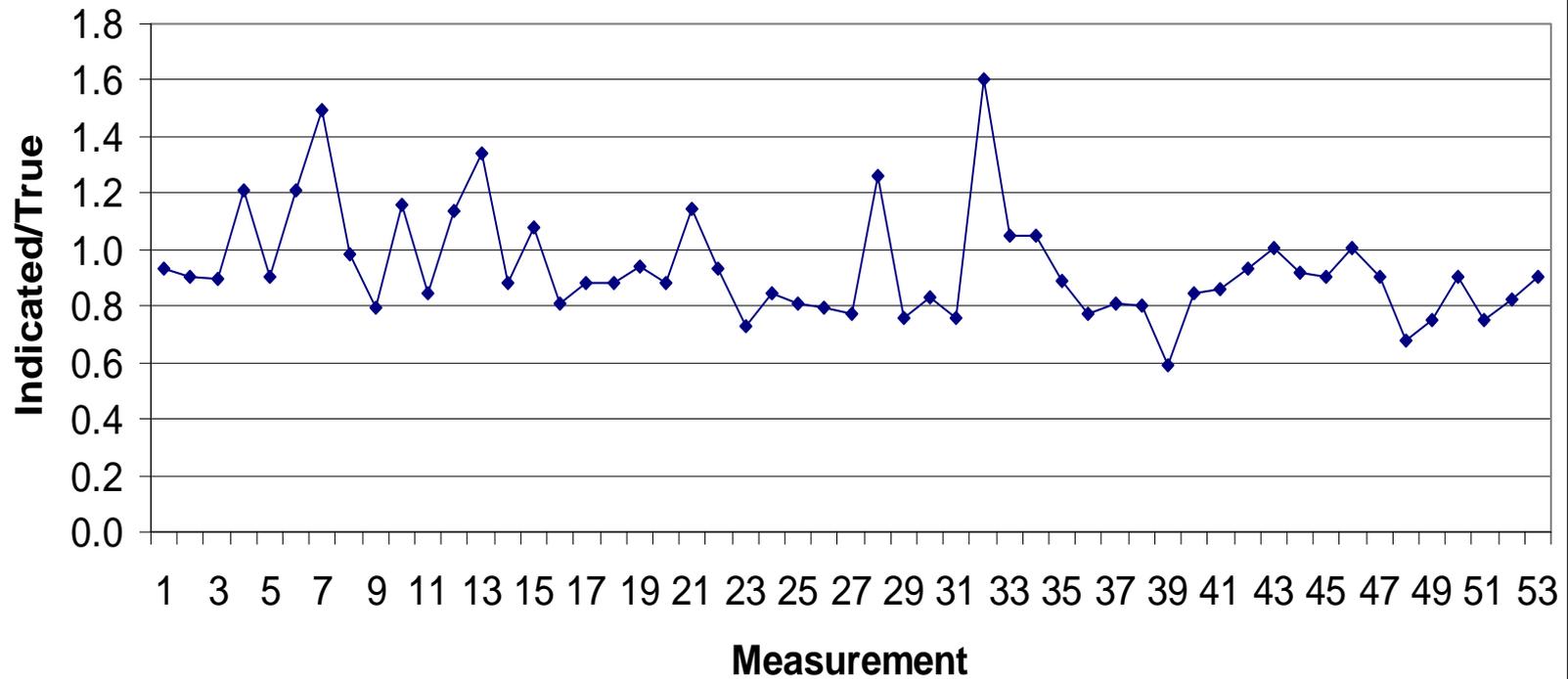
Calibration method using gamma radiation

How do we do it?

- On the Overhoff 1400 disconnect the polarising voltage lead from the gamma compensation chamber.
- Or on the Scintrex 309A disconnect the battery to the compensation chamber and short out the connector.
- Use a gamma calibration facility with traceable dose rates to test the monitors.

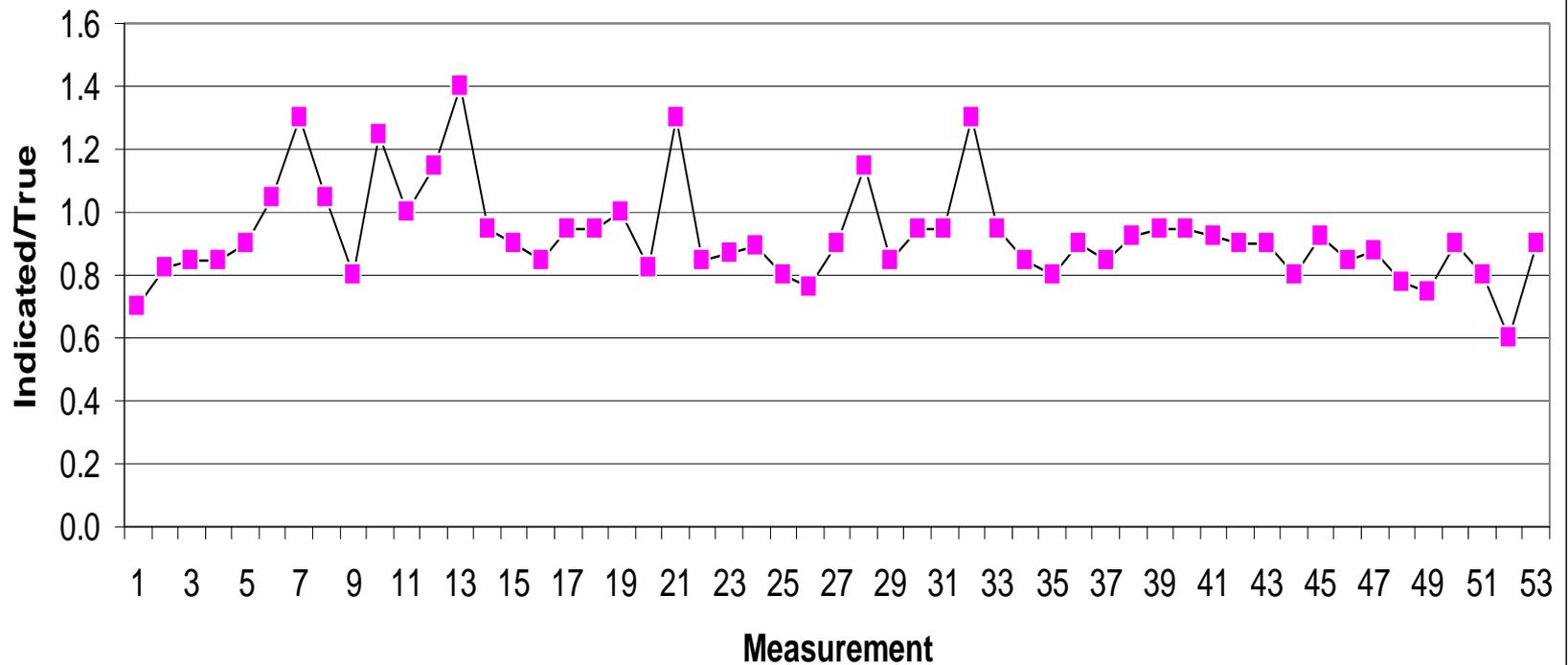
Collated results from 52 calibrations

H3 results Indicated/True Overhoff 1400



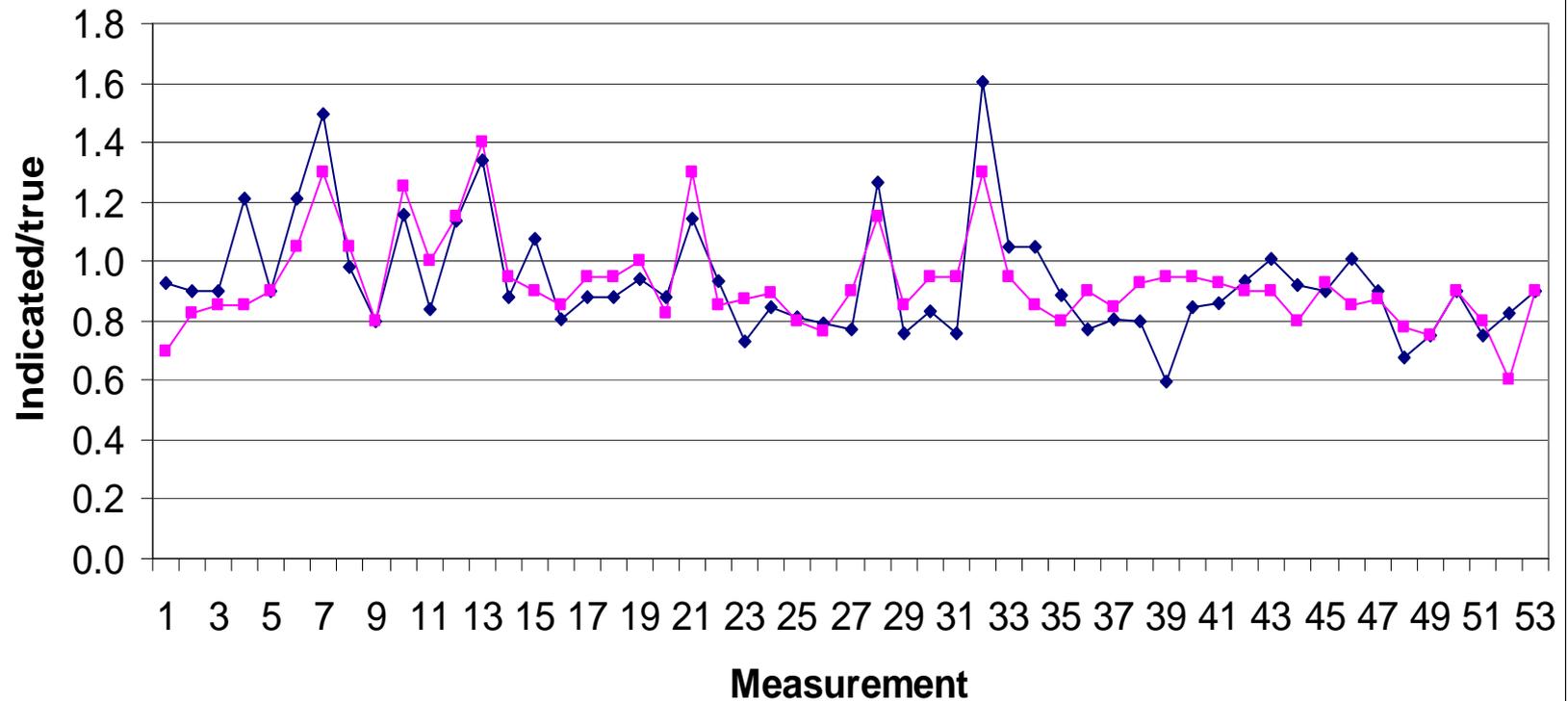
Collated results from 52 calibrations

Gamma results Indicated/True Overhoff 1400



Collated results from 52 calibrations

Gamma - H3 results combined Overhoff 1400



Very brief analysis

- There is a close correspondence between the I/T values for the ³H measurements and the I/T values for the gamma measurements using a value of $3 \mu\text{Sv.h}^{-1} \cong 1\text{MBq.m}^{-3}$.
- From the 52 measurements we distilled the following data:

	Mean cal factor Response I/T Tritium	Mean Cal factor response/gamma equiv. Conc	Ratio: H3 result/gamma result
	0.94	0.93	1.01
SD 1 sigma =	20.8%	17.0%	14.7%

Conclusion

- H³ sources that can test the more common H³ in air monitors across their full range are difficult to obtain, and probably undesirable, because it may contaminate the chambers.
- The data presented here strongly suggest that gamma radiation can be used to fully test tritium monitors across their full range and this will reduce the need to use expensive specialised H³ facilities.
- H³ facilities will always be required for type testing and confirming gamma calibration data.
- We hope this guide will provide useful advice on how to calibrate and test tritium monitors in a cost effective way and without inadvertently contaminating the ionisation chambers.
- A very rough draft has already been produced. We are currently working on sections that will describe the calibration and testing of 'Installed tritium monitors'.
- We would hope to have a draft for ARMUG to comment on by May 2008.
- I would like to thank the working group and my colleague Reg Bosley for their help in producing this presentation.