

TRITIUM - IS IT UNDERESTIMATED?

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INTRODUCTION

The Whitlock Tritium Meter was first introduced to the IRPA as a simple and satisfactory method for the direct measurement of Tritium surface contamination, at the 4th International Congress, Paris 1977. It was shown then that though instrumentally the measurements can be made simple, the fundamental characteristics of Tritium air absorption and self-absorption must be clearly understood, if the results of measurements are to be meaningful.

Practical experience of the author in the use of the Whitlock Tritium Meter in various laboratories and industrial establishments throughout the world since its first development has shown that:

- a. Measurements by smear/wipe tests can often be in error by three orders of magnitude or more.
- b. Sub-visual scratches (8μ deep) are radiologically important.
- c. Volatile forms of Tritium exist in 20% to 30% of establishments visited.

The author questions the widespread use of smear/wipe techniques for the assessment of 3H surface contamination based on the assumption that 10% of removable activity is collected by the smear/wipe.

Tritium surface contamination assessed as "fixed" can contain volatile fractions with a hazard potential which may be considerably greater than the hazard from removable activity at present covered by the Maximum Permissible Level (MPL) recommendations.

The Whitlock Tritium Meter has now been used for radiation protection purposes for six years in all manner of working environments, from Atomic Power Station, to Pharmaceutical laboratories. In addition, the author has demonstrated its use in several hundred establishments for direct measurement of suitable surfaces [1] and the rapid assay of smears.

During this time it has been of concern to observe a discrepancy in measurements which indicate that smear sampling techniques can be in error by a factor of 1000 or more. Of particular significance were surveys of several working surfaces [2] in separate establishments which had been shown clean or well below the MPL [Maximum Permissible Level] - notes [1] and [2] by smear surveys carried out by independent authorities a short

time previously.

Direct measurement of these surfaces, using the Whitlock Tritium Meter, revealed a residual activity estimated to be in excess of 1000 times the Maximum Permissible level. A reduction of this activity was observed when surfaces were de-contaminated with detergent and water. Successive cleanings reduced the total activity in a quasi exponential way.

The potential error in the assay of activity on the smears by Liquid Scintillation counting would be very unlikely to be greater than a factor of 2 or 3.

With regard to the smear, at the time when direct measurements were made, the surfaces appeared clean. The activity detected was not in the form of dust particles, and at that moment of time could be considered bound i.e. not easily removable activity. Thus we could conclude that the activity was fairly firmly fixed to the surface and as such the contamination indicated by smear was within the recommended levels.

However, consideration must be given to the following points:

1. With such a high activity present should only 0.1% become unbound by the day or week following the survey the Maximum Permissible Level even in the terms of removable surface contamination would be exceeded.
2. The assumption that the activity was "bound" is not necessarily correct. It was observed that large areas of the working surfaces surveyed by smears were covered with almost sub-visual scratches and activity in these may not be readily collected by a smear.
3. The isotope we are dealing with is Tritium, and the exposure pathways include absorption through the skin [3] as well as inhalation of dust particles.
4. In addition we have potential inhalation of volatile fractions [described later].

The main point of concern relative to these observations is that the present reliance on the smear technique to give reliable information as to the actual contamination hazard is unjustified, even if the technique is only applied to smooth working surfaces as defined in the Codes of Practice. They would also suggest that radiological protection consideration of Tritium contamination should be based upon a direct measurement of surfaces contamination, if necessary by the provision of a suitable surface in locations where surfaces suitable for direct measurements [1] would not normally be available. Assumptions for the surrounding work surfaces can then be made relative to factual information.

If our findings are representative of working surfaces everywhere, they illustrate a potentially hazardous situation on a world wide scale, for they apply not only to laboratories where high levels of Tritium are used, but even low level laboratories, because the problem is not due to a "one-time" large spill, but a gradual history

of build-up due to poor house-keeping, as a result of highly inaccurate measurements giving a false sense of security.

The high inaccuracies in measurements also extend to certain types of Tritium sensitive survey instruments, capable of making direct measurements of very small areas of the working surface which, because of the very small sensitive areas (1.6 to 10cm^2) of the detectors, encourage the survey of a surface by a sweeping or scanning technique commonly adopted for isotopes emitting more energetic betas than Tritium, enabling the use of geiger counters. Here the problem of the integration time constant of rate meter instruments is often forgotten, and areas are covered more quickly than the probe area really permits. This is compounded by the very severe absorption by air of Tritium betas (range typically 0.5mm for 5.6 keV betas [1]). Lack of appreciation of the severe limitation imposed by this fundamental characteristic leads to the conduct of surveys where the detector is held outside the range of a significant number of emitted betas which, in turn, produces a potential error of infinity. As is the case with smear measurements, direct measurement by hand held devices can result in the conclusion that it is safe to continue working in the areas surveyed with the erroneous conviction that the contamination is below the Maximum Permissible Level.

To this situation we must add that in 20 - 30% of the establishments in which we have made direct surface measurements, using the Whitlock Tritium Meter, we find the presence of volatile Tritium. At first sight this would appear to be of academic interest, but on further consideration the radiological hazard could be considerable, and most likely specific to one individual among the personnel in the working environment. The Whitlock Tritium Meter detects the presence of volatile Tritium by virtue of the fact that a vacuum of approximately half of an atmosphere is established in the measuring chamber for each measurement. If volatile fractions do exist, they are "driven off" and can be identified by successive measurements (10 seconds each) of the same area (100 cm^2). It is clear that we do not live in an environment where the atmospheric pressure suddenly changes 50%, so the condition is artificially emphasised, nevertheless, it is quite within the bounds of possibility that working surfaces will be subjected to temperature changes; for instance, sunlight through a window sweeping across the surface, or more likely, in consequence of a hot object, such as a human hand, or a recently heated beaker, being placed on the surface. In such circumstances, the volatile fraction given off will form an active "cloud" local to the person carrying out the work.

As we have seen from the previous discussion the source from which it comes can quite easily be several thousand times greater than the Maximum Permissible Level.

The active cloud would not readily be detected by installed Tritium in air monitoring equipment, due to the dilution volume of the room, or by urine tests, because of subsequent dilution [usually] in the total body water. The hazard seems likely to be the same as inhalation of dust particles from surface contamination.

CONCLUSION

Evidence suggests that the question of Tritium surface contamination should be re-considered in its entirety as the actual hazard may widely exceed acceptable levels. In particular the question of calibration of the smear technique, the effect of surface condition and the hazard of volatile fractions need investigation.

REFERENCES

1. G D Whitlock - "Tritium Contamination Measurement A Simple and Satisfactory Method " - Proceedings 4th Congress IRPA Vol 3 Pages 809 -812
2. Manufacturers trade marks - Formica, Wearite
3. J A Gibson and A D Wrixon - "Methods for the Calculation of D.W.L's - for Surface Contamination by Low-toxicity Radionuclides" - Health Physics Vol 36 [March] Page 318

Note 1: The M.P.L. [Maximum Permissible Level] referred to in the text = $10^{-4} \mu\text{Ci}/\text{cm}^2/100\text{cm}^2$

Note 2: There is no derived working limit [DWL] for Tritium