| Office of Compensation Analysis and Support<br>Technical Information Bulletin | Document Number: OCAS-TIB-009<br>Effective Date: (4/13/2004)<br>Revision No. 0 |
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| Estimation of Ingestion Intakes | Page 1 of 5 |
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RECORD OF ISSUE/REVISIONS

| ISSUE AUTHORIZATION DATE | EFFECTIVE DATE | REV. NO. | DESCRIPTION |
|---|---|---|---|
| 4/13/2004 | 4/13/2004 | 0 | New document to provide a standardized approach to estimating ingestion intakes. |

## 1.0 PURPOSE

This Technical Information Bulletin provides guidance to be used for estimating intakes of radioactive material through ingestion.

## 2.0 Background

Radioactive materials can enter the body through several routes of entry. The most likely is inhalation but in some facilities, ingestion can not be ruled out. At many facilities, internal exposure is assessed using bioassay. When this is the case, the most likely and most claimant favorable assumption is normally to consider all the exposure to be by the inhalation pathway. However, in some cases, no bioassay is available and internal exposure is estimated using other means. Normally the airborne concentration of radioactive materials will be estimated using air samples or some other means but this method of estimating exposure would miss any additional intakes via the ingestion route. This Technical Information Bulletin (TIB) has been written as a standard method of addressing ingestion in those cases when preparing a site Technical Basis Document. In cases where more relevant information is available, that information should be used in lieu of this TIB.

## 3.0 Approach

This TIB categorizes the ingestion route into several potential modes and then analysis each mode separately. Ingestion can be categorized into three modes.

1 Inhaled material is caught in the mouth or removed from the lungs to the gastrointestinal tract by normal lung function.
2. Material in the air settles out onto food or drink which is later ingested.

3. Material is transferred from contaminated surfaces to an individuals hand and then ingested.

Mode 1
The first mode is accounted for in the inhalation calculation through the use of the ICRP 66 lung model. No further assignment of ingestion dose from this mode is required.

Mode 2
This mode applies to the settling of material from the air to food or drink. The settling onto food is considered low. Most food is kept in a container or wrapping and opened just prior to eating. This is especially true in a dusty environment (the dose from this mode of ingestion would be small if not in a dusty environment). It is possible to transfer contamination from the hands to the food (such as a sandwich) but that mode is explored in ingestion mode 3.

The amount of material settling into a drink would depend primarily on the size and type of the opening of the drink, how long the drink is in the area before it is consumed, and if and how often residual drink is dumped or rinsed out of a reusable container (such as a coffee cup). These criteria will be maximized for this analysis so that the container is assumed to have an open top with a three inch diameter (such as a coffee cup). It is assumed to be in the area the entire work day and it is assumed that all the drink is consumed (none was disposed of).

It should be noted that this estimate would not account for material settling directly onto food. It is assumed that this pathway would be small since food stored in a dusty environment is likely contained in some manner. However, this TIB provides a reasonably high estimate of the amount ingested from drink in order to account for the possibility.

Mode 3
This mode applies to the transfer of material from contaminated surfaces to an individual's hands and subsequently the ingestion of that material. For this mode, only the readily removable material is important. The primary source of removable surface contamination is the settling of airborne dust onto horizontal surfaces. Removal mechanisms can include natural or forced ventilation, housekeeping, and resuspension into the air.

This analysis will assume that the only removal mechanism is the transfer of material from the surface to an individual's hands. An equilibrium contamination level can then be calculated in which the deposition of contamination (from the settling of airborne contamination) is equal to the removal rate (from transfer to hands).

## 4.0 Calculations

Settling Rate

For this analysis, the calculated terminal settling velocity of 0.00075 m/s is used. This value is multiplied by the airborne concentration (in activity per $m^3$) to arrive at the rate at which contamination is settling onto horizontal surfaces (in activity per $m^2$ per sec.).

Mode 2 calculation

Using the assumptions described above for mode 2, the activity that settles into a 3 inch diameter coffee cup over the course of an 8 hour day can be calculated as follows.

A pCi/$m^3$ * 0.00075m/s * 0.00456$m^2$ * 8hours * 3600 sec/hour = 0.0985 * A pCi

This implies that activity ingested on a daily basis from this mode is equivalent to approximately 10% of the activity per cubic meter in air. For clarity, the activity unit of pCi was used in this example but the result is the same for any activity unit.

Mode 3 calculation

Using the assumptions described above for mode 3, and equilibrium surface contamination can be determined by assuming the rate that contamination is deposited equals the rate that it is removed.

R = k*S

Where:
R = the rate material settles out of the air (A pCi/$m^3$* 0.00075 m/s)
K = the fraction of surface contamination removed each day
S = the surface contamination level (pCi/$m^2$)

Once this contamination level is determined, the amount of activity on the individuals hand is assumed to be some fraction (Fh) of this level. The amount of activity actually ingested is assumed to be some fraction (Fi) of the activity on the individual's hand. A study was done at the Oak Ridge Gaseous Diffusion Plant (ORGDP) to determine the intake of uranium from hand contamination. The study indicated that the amount of uranium that is transferred from the hand to the cigarette while smoking was approximately 1% of the material on the surface of the hand (Bailey 1958). For this analysis, that fraction is assumed to be 10%. Therefore, the amount of activity ingested from this mode can be calculated as:

R/k *Fh * Fi = ingested activity
Or
A pCi/$m^3$ * 0.00075 m/s / k * Fh * Fi * 24 hours * 3600 sec/hour * 0.0155 $m^2$
= activity ingested.

Note that 0.0155 $m^2$ represents the surface area of a four inch by six inch hand. Also note that the time interval is 24 hours. That accounts for the possibility of 24 hour per day operations.

Since the assumption was made that the only removal mechanism is the transfer of material to the individual, Fh = k and these two terms cancel out. Inserting 0.1 (10%) for Fi then give us:

A pCi/$m^3$ * 0.00075 m/s * 0.1 * 24 hours * 3600 sec/hour * 0.0155 $m^2$
= 0.100 * A pCi/$m^3$

This implies that activity ingested on a daily basis from this mode is equivalent to approximately 10% of the activity per cubic meter in air. The activity unit of pCi was used in this example but the result is the same for any activity unit.

It should be noted that it is likely an individual would transfer removable contamination from many locations in the facility. Each of these individual transfers would accumulate on the individual's hands. The number of horizontal surfaces an individual touches throughout his work day would be difficult to accurately estimate. Therefore, this analysis assumes that the individual transfers contamination from only one surface to his hand. While at first this may appear to be unrealistically low, it should be noted that the favorable parameters in this analysis causes the contamination on the individuals hand to equal the amount of activity deposited on the floor though the course of an entire 24 hour period.

## 5.0 Conclusions

It should be noted that while the length of the work day was used in this calculation, the result was based on a fraction of the airborne activity. If a different length workday is used, the ingested activity from mode 2 can be adjusted to account for that. The ingested activity for mode 3 is unaffected since it assumes 24 hours per day settling.

The amount of activity ingested on a daily basis can be approximated by assuming it to be 0.2 times the activity per cubic meter of air. The f1 value for the ingestion should be the same as that used for inhalation.

## 6.0 References


1 Bailey, J.C., "Personnel Contamination as a Uranium Hazard," in Symposium on Occupational Health Experience and Practices in the Uranium Industry, HASL-58, Health and Safety Laboratory, U.S. Atomic Energy Commission, New York Operations Office, October 15-17, 1958.

2. ICRP (1994) *IHuman Respiratory Tract Model for Radiological Protection.* ICRP Publication 66. Annals of the ICRP 24 (1-3). Pergamon Press, Oxford, UK.