

# Surface Contamination Limits

Med Phys 776

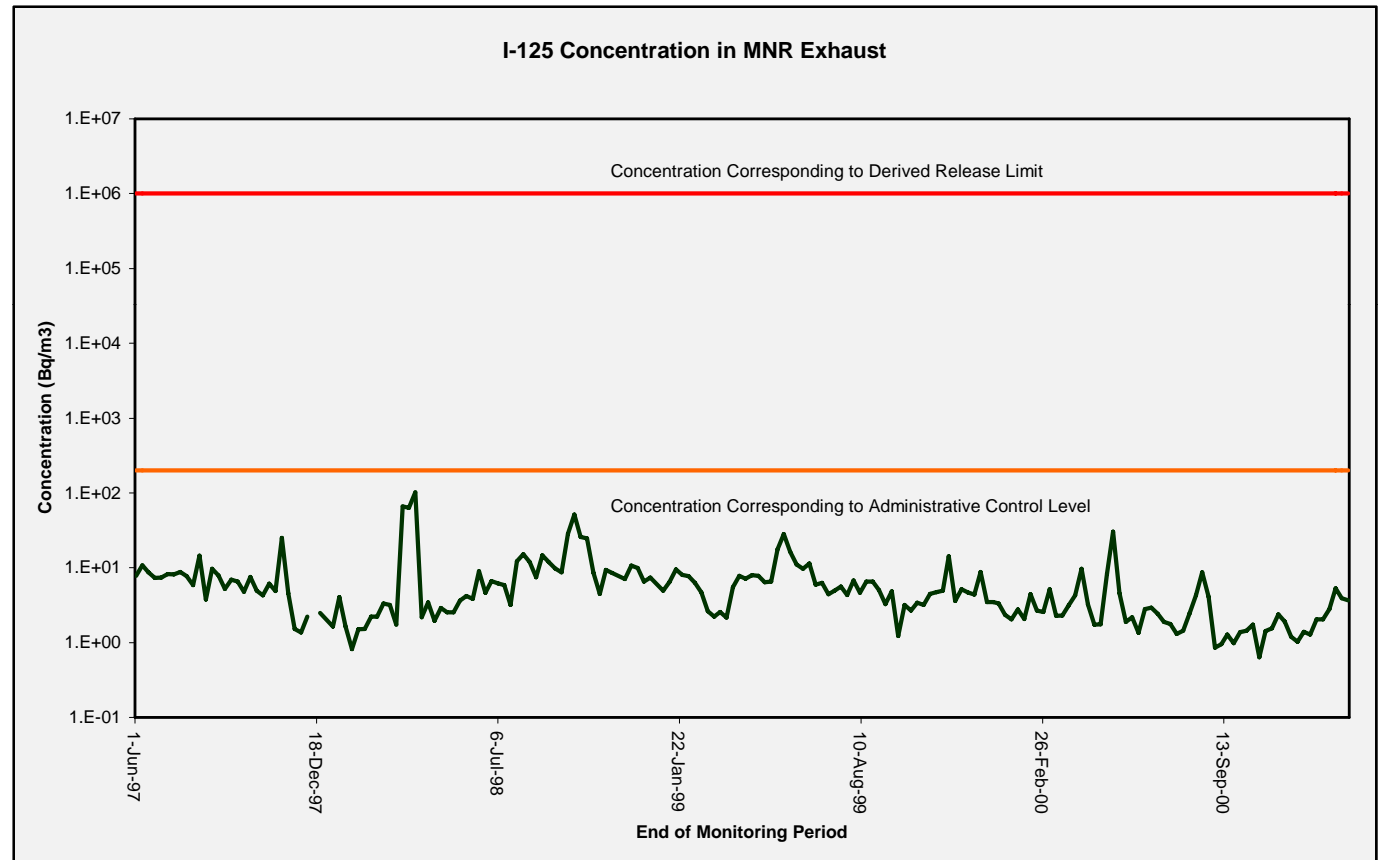
2004 February

# Objectives of Contamination Monitoring

- Maintain doses to workers and members of the public ALARA
- Monitor the effectiveness of containment systems and working practices
- Assist in preventing spread of contamination to areas such as low level counting and research areas
- Provide information for work planning, air monitoring and internal dosimetry programs

# Two Types of Monitoring

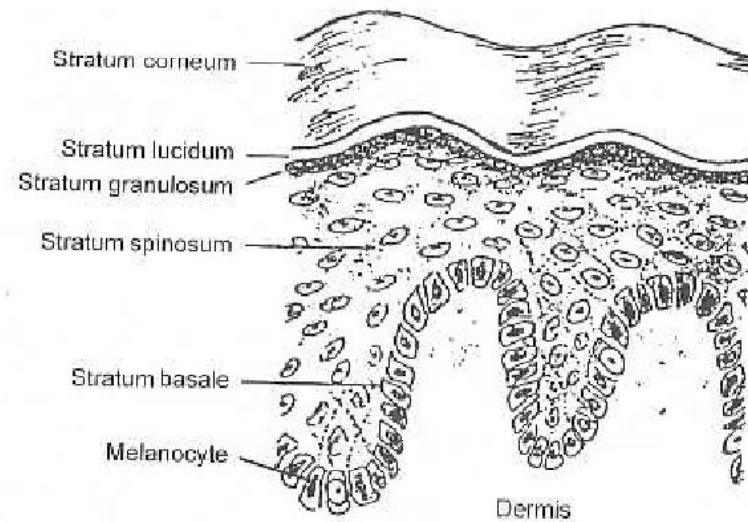
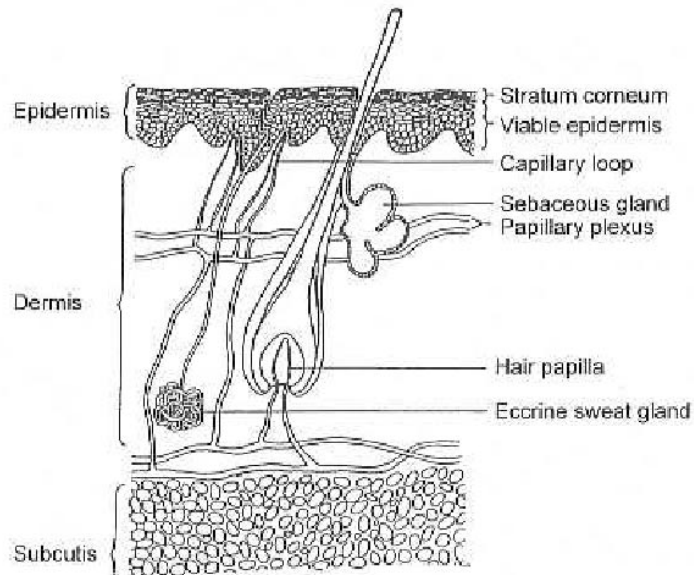
- Baseline
- Operational
- It is necessary to establish limits – how much is too much?



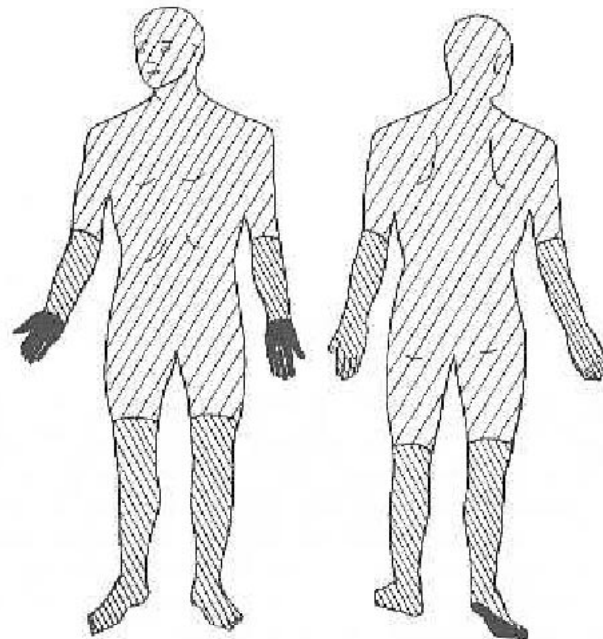
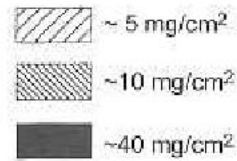
# Doses from Surface Contamination

- External irradiation
  - material deposited on the skin
  - dominated by betas and energetic electrons
- Inhalation of re-suspended material
  - $1\text{E-}5$  to  $1\text{E-}6$   $\text{m}^{-1}$  ratio between surface contamination levels and airborne contamination levels under normal conditions
- Ingestion of radioactive material transferred to hands
- Absorption of radioactive material through the skin
  - retention in the skin can be significant in rare instances (I-125)
- Removable vs. Non-Removable surface contamination

# Skin



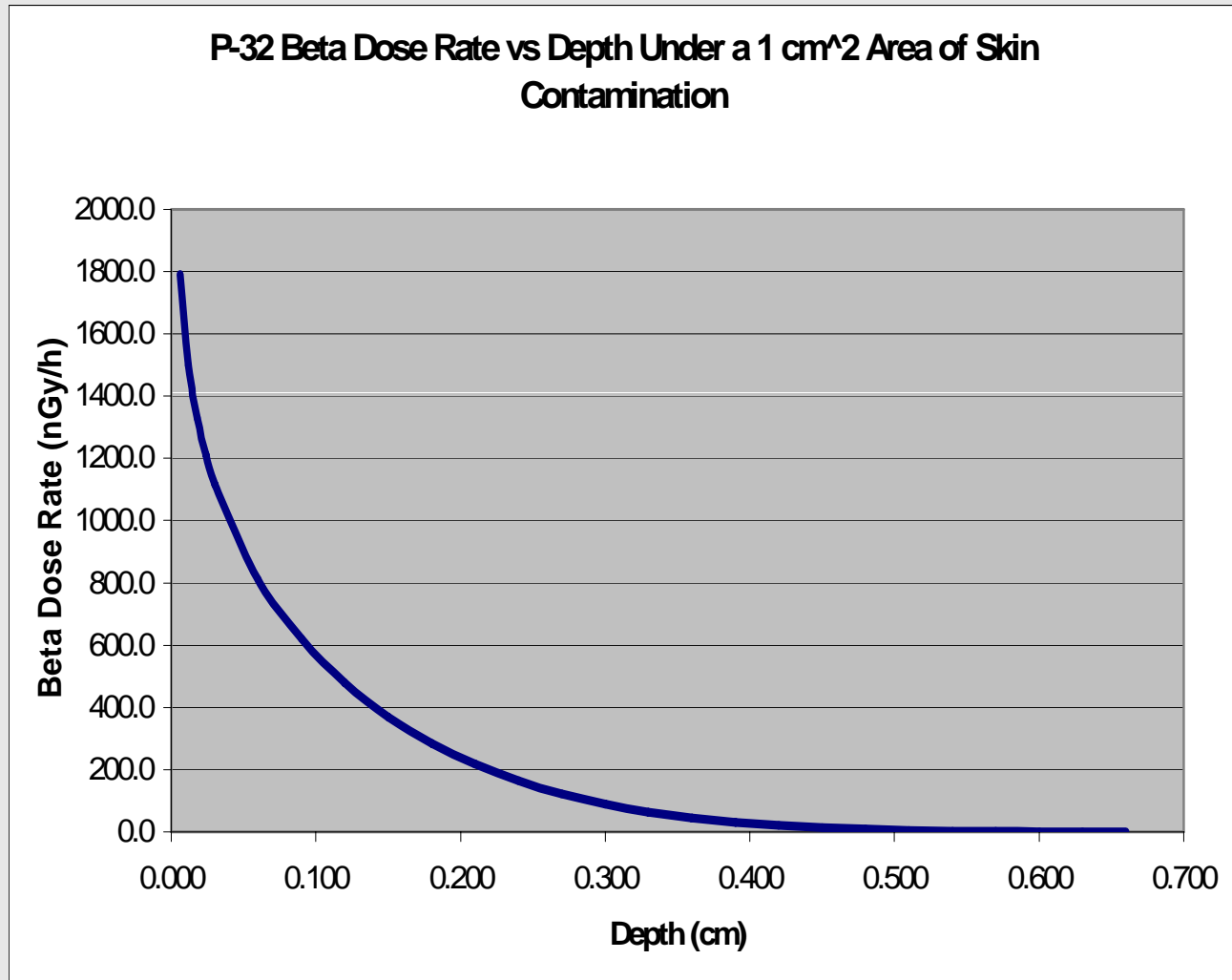
# Varying Thickness of Epidermis



**P-32**

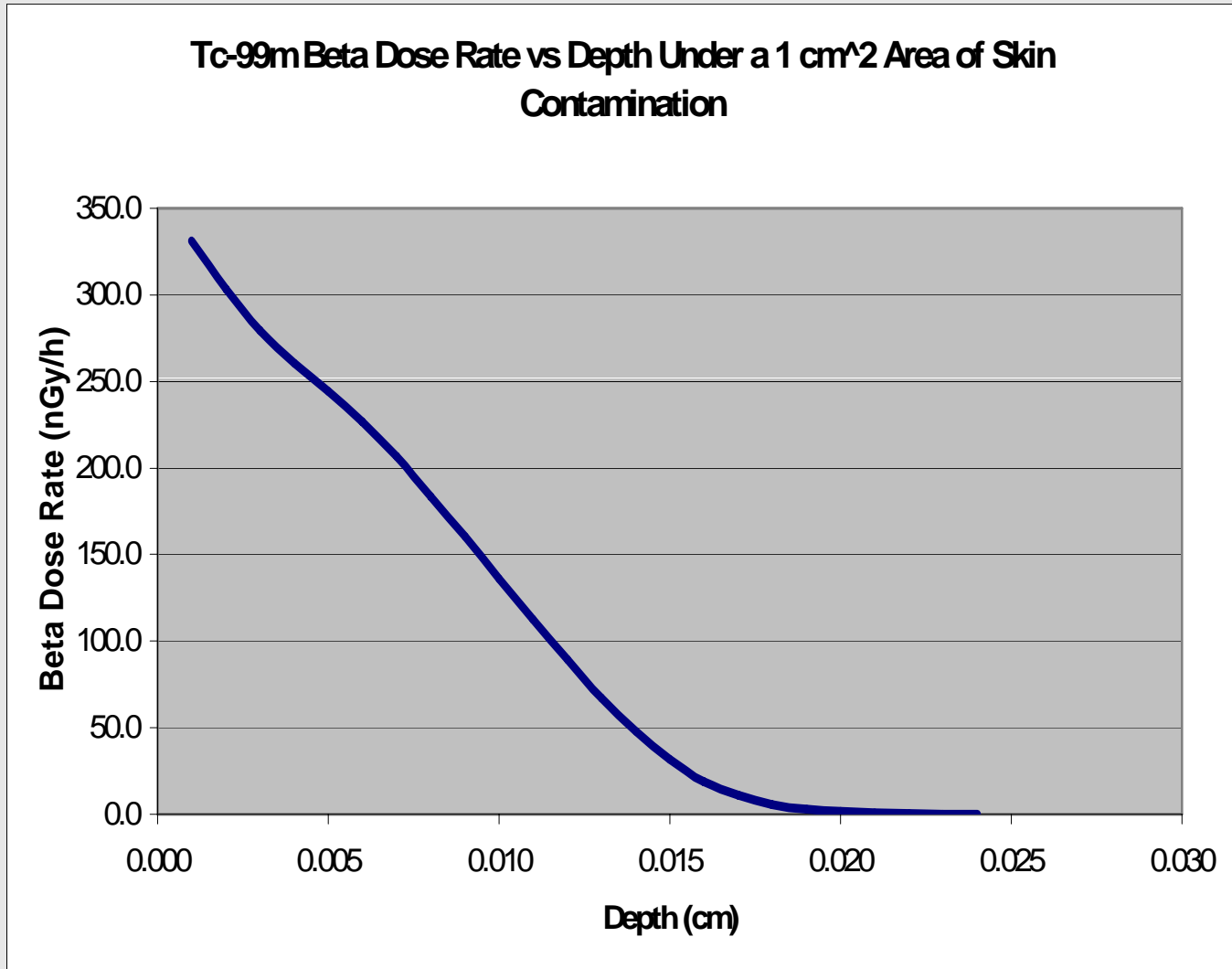
**Depth (cm) Dose Rate (nGy/h)**

0.006	1790.9
0.012	1499.9
0.018	1331.0
0.024	1211.2
0.030	1116.9
0.060	811.5
0.090	620.6
0.120	478.4
0.150	369.8
0.180	284.9
0.210	217.7
0.240	164.3
0.270	122.3
0.300	89.5
0.330	64.3
0.360	45.3
0.390	31.2
0.420	20.9
0.450	13.6
0.480	8.5
0.510	5.1
0.540	2.9
0.570	1.6
0.600	0.8
0.630	0.4
0.660	0.1



**Tc-99m**

<b>Depth (cm)</b>	<b>Dose Rate (nGy/h)</b>
0.001	331.2
0.002	303.5
0.003	279.3
0.004	260.7
0.005	244.2
0.006	226.9
0.007	206.7
0.008	183.6
0.009	160.4
0.010	136.1
0.011	112.7
0.012	89.6
0.013	67.2
0.014	48.0
0.015	31.5
0.016	18.7
0.017	11.0
0.018	5.5
0.019	3.1
0.020	1.7
0.021	1.0
0.022	0.5
0.023	0.2
0.024	0.1



# ACRP-7 Exposure Pathways

- external irradiation of skin due to contamination on the surface
- ingestion of a fraction of contamination from contaminated skin
- inhalation of re-suspended contamination
- uptake of the radionuclide via absorption through the skin
- skin dose from a radionuclide retained in the skin.

Surface	Pathways Considered	Dosimetric Parameters
Personal Skin Contamination	External irradiation Inhalation Ingestion Uptake through skin	Occupational dose limit Exposure time of 8760 hours
Personal Clothing	External irradiation Inhalation Uptake through skin	Occupational dose limit Exposure time of 4000 hours
Protective Clothing	External irradiation Inhalation Skin Uptake	Occupational dose limit Exposure time of 2000 hours
Controlled Area Surfaces	External irradiation Inhalation Skin Uptake	Occupational dose limit Exposure time of 2000 hours
Uncontrolled Area Surfaces and Equipment Leaving a Controlled Area	External irradiation Inhalation Ingestion Uptake through skin	Standard is 1/20 <sup>th</sup> of that for Controlled Area Surfaces. (Practice is 1/10 <sup>th</sup> )

## External Irradiation

$$DWL = \frac{H_L}{T_c (DCF)_e} \text{Bq} \cdot \text{m}^{-2}$$

Where

$H_L$  = annual dose limit = 500 mSv  $y^{-1}$

$T_c$  = exposure time

= 8760 hours  $y^{-1}$  for skin contamination

= 4000 hours  $y^{-1}$  for contamination of personal clothing

= 2000 hours  $y^{-1}$  for contamination of protective equipment and controlled area surfaces

$(DCF)_e$  = external dose conversion factor to basal layer of skin

### Inhalation

$$DWL = \frac{ALI}{I_a R_s} \text{Bq} \cdot \text{m}^{-2}$$

Where

ALI = Annual Limit on Intake (Occupational)

$I_a$  = inhalation rate ( $\text{m}^3 \text{y}^{-1}$ )

=  $3600 \text{ m}^3 \text{y}^{-1}$  for contamination of skin and personal clothing

=  $2400 \text{ m}^3 \text{y}^{-1}$  for contamination of protective equipment and controlled area surfaces

$R_s$  = resuspension factor for particulate material from surfaces

=  $5 \times 10^{-5} \text{ m}^{-1}$  (for most materials)

## Ingestion

$$DWL = \frac{ALI}{A_s f_a N_c} \text{Bq} \cdot \text{m}^{-2}$$

Where

ALI = Annual Limit on Intake (Occupational) by ingestion

$A_s$  = area of skin being considered - normally taken as the area of the hands  
=  $0.03 \text{ m}^2$

$f_a$  = fraction of activity on the skin that is ingested  
= 0.1

$N_c$  = number of contamination events per year - normally taken as once per working day  
= 250

## Uptake by Skin

$$DWL = \frac{H_L}{(DCF)A_s f_u N_c} \text{Bq} \cdot \text{m}^{-2}$$

Where

$H_L$  = Annual Dose Limit

= 20 mSv  $y^{-1}$

DCF = Dose Conversion Factor for the critical organ or tissue

$f_u$  = fraction of activity on the skin surface that is taken up into the body through the skin

= 0.1 for tritiated water, 0.002 for radioiodine

$N_c$  = number of events per year

= 250 based on once per day

## Uncontrolled Areas

For Uncontrolled Areas, ACRP recommends that the application of the equation for the ingestion pathway be modified as follows:

$$DWL_{UA-I} = \frac{ALI}{A_s f_a N_c} \text{Bq} \cdot \text{m}^{-2}$$

Where

ALI = Annual Limit on Intake (Occupational) by ingestion / 20 (ratio of occupational to public)

$A_s$  = averaging area for contamination measurements (nominally set to  $0.01 \text{ m}^2$ )  
=  $0.01 \text{ m}^2$

$f_a$  = fraction of activity on surface that is ingested  
= 0.1

$N_c$  = number of contamination events per year - normally taken as once per working day  
= 250

Or  $1/20^{\text{th}}$  that for Controlled Areas

Calculated Derived Working Limits for I-125 Contamination (Bq cm<sup>-2</sup>)

Surface	External Exposure	Inhalation	Ingestion	Skin Uptake	Retention in Skin
Personnel Skin Contamination	3.0 E 3	1.1 E 3	1.3 E 2	4.5 E 2	1.4 E 2
Personal Clothing	6.5 E 3	1.1 E 3	NA	4.5 E 2	1.4 E 2
Protective Clothing	1.3 E 4	1.7 E 3	NA	4.5 E 2	1.4 E 2
Controlled Area Surfaces	1.3 E 4	1.7 E 3	NA	4.5 E 2	1.4 E 2
Uncontrolled Area Surfaces (and equipment leaving a controlled area)	1.3 E 3	8.3 E 1	2.0 E 1	2.2 E 1	1.4 E 1