

# Taurus Advanced



The Taurus software package performs intake and dose calculations for internal radiological contamination in occupational exposures. It was developed by the UK Health Security Agency's Internal Dosimetry Group.

Taurus provides a simple graphical user interface (GUI) to UKHSA's internal dosimetry computer code Pleiades (Fell T.P. et al, 2007). Pleiades is written in Fortran and has been used for the calculation of reference dose coefficients and bioassay quantities published in the International Commission on Radiological Protection (ICRP) Occupational Intakes of Radionuclides series of publications (ICRP 2016b, 2017, 2019). Taurus thus implements the most recent ICRP recommendations (ICRP 2007) and the accompanying biokinetic, dosimetric models (ICRP 2009, 2015, 2016a, 2016b, 2017, 2019, 2022) and radiological decay data (ICRP 2008).

In addition to calculating radionuclide activity in organs and excreta and committed doses due to occupational exposures, Taurus also estimates radionuclide intakes from bioassay data. Taurus uses the well proven maximum-likelihood fitting module previously used in UKHSA's IMBA software (Birchall et al, 2003) which can produce robust estimates of multiple intakes using several types of bioassay data, including censored observations (e.g. less than the limit of detection results). Activity and doses are given in S.I. units of becquerel (Bq) and sievert (Sv).

Plotting of measurements and bioassay predictions is through Dynamic Data Exchange with Dplot Graph software for scientists and engineers, by Hydesoft computing LLC, a freely distributable restricted functionality version of which (DPlot Jr) is included in the Taurus installation package. If a full version of DPlot is installed Taurus will benefit from the increased functionality which this provides.

The Taurus GUI was built using the Winteracter Portable Fortran user interface and graphics toolset by Interactive Software Services Ltd.

**Taurus Advanced** is intended to meet the needs of internal dose specialists and researchers and provides more advanced functionality than the base version. As with the base version, Taurus Advanced enables the user to:

- calculate equivalent organ doses and effective doses and bioassay quantities at pre-defined time-points from one or more specified acute or chronic intakes
- calculate doses and bioassay quantities at user-specified time points from one or more specified acute or chronic intakes
- estimate single or multiple intakes from measurements of activity in the body and/or excreta and to calculate the resulting doses.

Some of the base functionality has been extended and new functions have been added in the advanced version:

- extended list of bioassay quantities
- allows the addition of up to five user-defined forms (absorption parameters)
- user-defined deposition parameters and particle transport rates for the respiratory tract
- uranium mixtures, plutonium-ameridium mixtures and user-defined mixtures
- NCRP wound model
- annual equivalent and absorbed doses (for compensation scheme calculations), sorted by year or organ/tissue

- linked intake regimes
- Bayesian tool for the calculation of posterior distributions for intake(s) and effective dose

## Main screen

The screenshot shows the Taurus software interface with the following sections:

- Input:**
  - Reference:** Co60\_3ir\_tau\_bay
  - Nuclide:** Co-60 5.2713y
  - Deposition parameters:** ICRP OIR series defaults, Light work, 5.0 microns AMAD
  - Absorption parameters:** ICRP OIR series defaults
  - Systemic biokinetics:** ICRP OIR series defaults
  - Alimentary tract:** ICRP OIR series defaults
  - Respiratory tract:** ICRP OIR series defaults
  - Wound model:** NCRP defaults
- Intake regimes:**
  - Number of intake regimes (max. 20): 3
  - Retrieve forms, Help: Forms
  - Reference year: 1901, End year: 2022
  - Table with columns: LR, LRfrac, Dep, Form, Route, Mode, Start, End, Intake, fA, fr, sr, ss, fb, sb
- Bioassay quantities:**
  - Whole body: [checked]
  - Lungs: [unchecked]
  - Adipose: [unchecked]
  - 24h Urine: [checked]
  - 24h Faeces: [unchecked]
  - Wound: [unchecked]
  - Blood: [unchecked]
  - Thyroid: [unchecked]
  - Skeleton: [unchecked]
  - Liver: [unchecked]
  - Kidneys: [unchecked]
  - GI tract: [unchecked]
- Calculations:**
  - Quick dose and bioassay
  - Prospective calculation
  - Retrospective calculation (data fitting) [selected]
  - Start calculations
  - Progress bar
- Results:**
  - Total effective dose, Sv: 1.24E-07
  - View equivalent doses
  - View absorbed doses
  - Goodness of fit
  - Plot bioassay
  - Bayesian tool
- Report:**
  - short [selected], long [unchecked]
  - Save report
  - View report
- Licence information:** This copy of Taurus is registered to Internal Dosimetry Group for 5 users. It will expire on 19/02/2025.

The Main Screen is divided into three main functional areas:

- **Input** - where the user defines the parameters for the calculations
- **Calculations** - where the user can choose between two prospective and one retrospective types of calculation to be performed
- **Results** - where calculated doses, goodness-of-fit metrics, plots of measurements and bioassay predictions are accessible, including summary reports in html format.

## Nuclides and nuclide mixtures

The user can select from a drop-down menu one of the 880 nuclides which are included in ICRP OIR Parts 2, 3, 4 and 5.

The screenshot shows the 'Taurus' software interface. The 'Input' section is active, displaying a 'Reference' field with 'ref\_name\_max\_20chars'. The 'Nuclide' dropdown menu is open, showing a list of nuclides with their half-lives: Cs-137 (30.1671y), Cs-138 (33.41m), Cu-60 (23.7m), Cu-61 (3.333h), Cu-64 (12.700h), Cu-67 (61.83h), Dy-151 (17.9m), Dy-152 (2.38h), and Dy-153 (6.4h). The 'Deposition parameters' section is also visible, showing 'ICRP OIR series defaults' selected.

In addition, the user can choose from a number of pre-defined uranium and plutonium mixtures encountered in the nuclear industry and define other generic mixtures (with up to five nuclides).

The screenshot shows the 'Nuclide mixtures' dialog box. It has tabs for 'Uranium mixture', 'Pu-Am mixture', and 'Other mixtures'. The 'Number of mixtures' is set to 8. The 'Specify isotopic abundance as %' section has 'Activity' selected. The table below lists 8 pre-defined mixtures:

	Label	Pu-238	Pu-239	Pu-240	Pu-241	Am-241	Description
1	mix_Pu_Fuel	0.53	1.64	0.88	96.95	0.00	Fuel-grade Pu
2	mix_Pu_Weapon	0.94	6.36	1.50	91.20	0.00	Weapon-grade Pu
3	mix_Pu_LWR	1.47	0.24	0.36	97.85	0.08	Pu from LWR just after unloading
4	mix_Pu_LWR_15y	3.33	0.54	0.81	90.82	4.50	Pu from LWR after 15 years after unloading
5	mix_Pu_Comm	2.31	0.33	0.49	96.87	0.00	Spent commercial fuel of uranium, just after chemical separation
6	mix_Pu_LowExp	0.04	11.93	2.80	84.50	0.73	Low-exposure Pu 5 years after chemical separation
7	mix_Pu_HighExp	3.14	0.39	0.43	95.22	0.82	High-exposure Pu 5 years after chemical separation
8	mix_Pu_Heat	99.75	0.04	0.01	0.20	0.00	Heat source

## User-defined absorption parameters

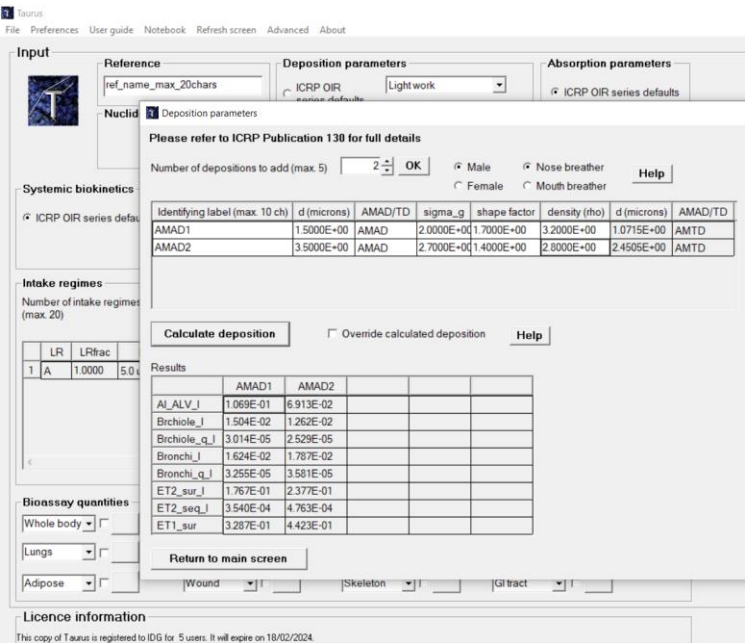
The user can define additional 'Forms' with specific absorption parameters for inhalation or ingestion.

The screenshot shows the 'Absorption parameters' dialog box. It has a title bar and a close button. The text 'Please refer to ICRP Publication 130 for full details' is displayed. The 'Standard representation' radio button is selected. The 'Number of forms to add' is set to 3. The table below lists 3 user-defined forms:

Identifying label (max. 10 chars)	fr	sr	ss	fb	sb	fA	Route
Form1	1.0000E+00	1.0000E+00	1.0000E-03	0.0000E+00	0.0000E+00	1.00E+00	Inhalation
Form2	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	2.50E-01	Ingestion
Form3	1.0000E-02	1.0000E-01	1.0000E-05	0.0000E+00	0.0000E+00	1.00E-01	Inhalation

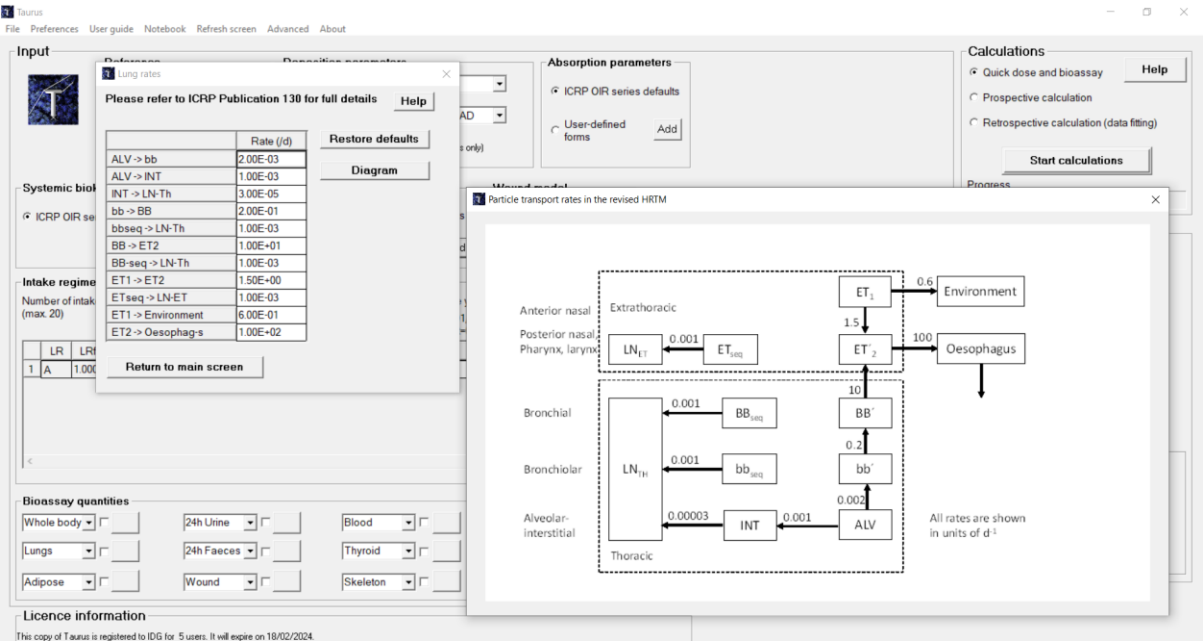
# User-defined respiratory tract deposition parameters

The user can set specific values for parameters used in the calculation of the deposition fractions, as aerosol parameters (particle size, density, etc).



# User-defined HRTM particle transport parameters

The user can set specific values for the particle transport rates of the revised Human Respiratory Tract Model (HRTM).



# Bioassay

Taurus can simultaneously calculate predictions over time for up to 12 common bioassay quantities. A bioassay quantity can be selected from a list of 52 different bioassay types.

Bioassay quantities

Whole body

Brunchi

Liver

Liver

Liver

LN-Th

Lung-Tis

Lungs

Muscle

Oesophagus

Ovaries

Pancreas

Lungs

24h Faeces

Wound

Liver

Kidneys

GI tract

Help

Licence information

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Taurus can calculate bioassay predictions (activity in organs or excretions) at specific time-points and calculate intakes from measurements (up to a total of 2000 measurements) :

Whole body bioassay measurements and predictions

Help

Parameters for bioassay predictions

Create time series

Linear

Log

Starttime (d) 0.0000

Stop time (d) 0.0000

Send

Specify collection periods

N/A for Whole body

0.0000

Send

Parameters for measurement data

u distn L

Send

Uncertainty 0.0000

Send

Monitoring

AC-224

Help

Return to main screen

Bioassay predictions

Number of rows (max. 2000) 7 OK

Measurement data

Number of rows (max. 2000) 11 OK

	Specified	Collection	Activity	Time	Collection	Activity	LOD	Uncert-	u	Excl.	Predicted	Chi-
	time (d)	period (d)	(Bq)	(d)	period (d)	(Bq)		ainty, u	distn		(Bq)	square
1									L			
2									L			
3									L			
4									L			
5									L			
6									L			
7									L			
8									L			
9									L			
10									L			
11									L			

Monitoring

The user can select which nuclide to monitor, either the parent nuclide or one of the progeny nuclides in the decay chain. When calculations are done for a nuclide mixture, the user can specify which nuclide(s) have been monitored and, optionally, whether to monitor the parent nuclide or one nuclide of its progeny in the decay chain.

For example, for a Pu-Am mixture: monitoring total activity from Pu-238,Pu-239 and Pu-240 (left) or from Am-241as a parent nuclide plus Am-241 grown in as a daughter of Pu-241 (right).

Monitoring

PU-238

PU-239

PU-240

PU-241

AM-241

Help

Monitoring

PU-238

PU-239

PU-240

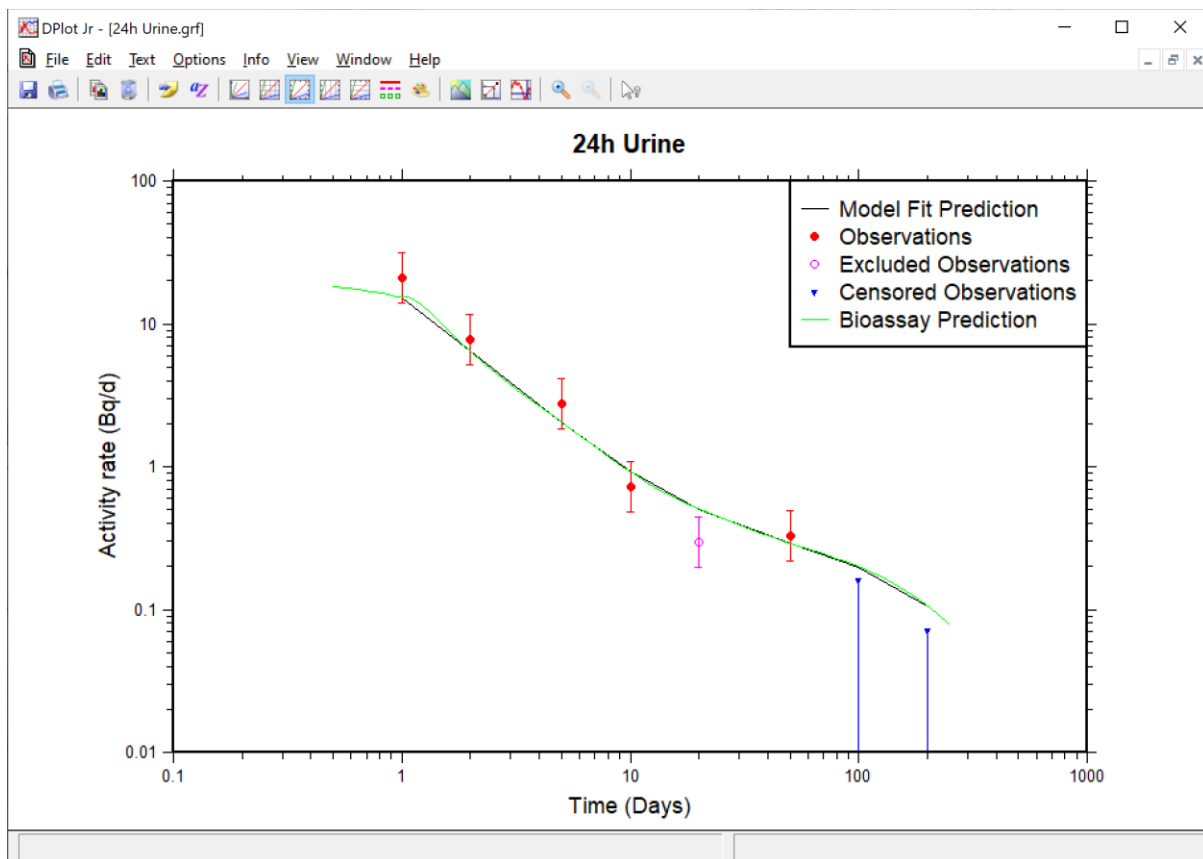
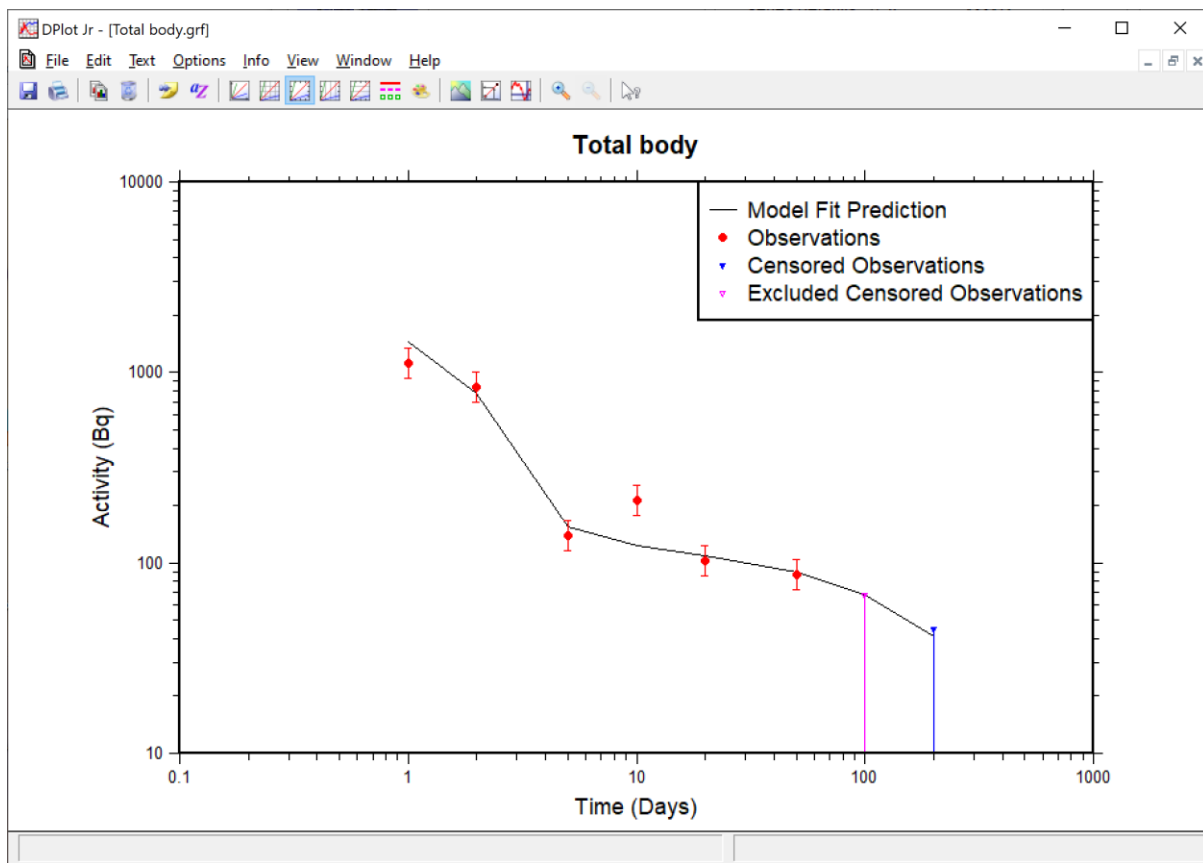
AM-241

AM-241

Help

Note that the selected monitoring nuclide is one of the progeny nuclides, not the parent nuclide.  
For more information, press the Help button.

## Plot of bioassay data



# View equivalent doses and annual absorbed doses

Committed effective doses and committed equivalent doses as well as annual absorbed (and equivalent) doses are shown once the selected calculation is completed.

## Tables for effective and equivalent doses (total and for each intake regime)

Male and female total equivalent organ doses (summed over all intake regimes) are shown: both the 50-year committed dose (table on the left) and the annual contribution (table on the right). Annual doses can be ordered either by year or by organ.

Equivalent doses, Sv

Total | IR 1 | IR 2 | IR 3 | IR 4 | IR 5 | IR 6 | IR 7 | IR 8 | IR 9 | IR 10 | IR 11 | IR 12 | IR 13 | IR 14 | IR 15 | IR 16 | IR 17 | IR 18 | IR 19 | IR 20 |

Total intake 2.0000E+00 Bq Total Effective dose (Sv) 6.94E-08

Total equivalent doses (Sv) Total annual equivalent doses (Sv)

	Male	Female
R-marrow	1.88E-09	2.40E-09
Colon	5.07E-10	5.78E-10
Lungs	4.93E-07	5.28E-07
St-stem	4.53E-10	5.05E-10
Breast	1.99E-10	2.22E-10
Ovaries	0.00E+00	5.88E-10
Testes	4.23E-10	0.00E+00
UB-wall	1.85E-10	2.33E-10
Oesophagus	3.86E-10	4.51E-10
Liver	3.21E-09	4.17E-09
Thyroid	2.92E-10	3.53E-10
EndostBS	1.18E-08	1.53E-08
Brain	2.01E-10	2.35E-10
S-glands	2.00E-10	2.31E-10
Skin	3.72E-10	5.30E-10
Adrenals	3.50E-10	4.01E-10
ET	7.38E-07	8.53E-07
GB-wall	2.29E-10	2.34E-10
Ht-wall	3.08E-10	3.85E-10

	Year	Intake this year (Bq)	Male	Female
R-marrow	1901	2.0000E+00	1.8755E-09	2.4031E-09
R-marrow	1902	0.0000E+00	0.0000E+00	0.0000E+00
R-marrow	1903	0.0000E+00	0.0000E+00	0.0000E+00
R-marrow	1904	0.0000E+00	0.0000E+00	0.0000E+00
R-marrow	1905	0.0000E+00	0.0000E+00	0.0000E+00
R-marrow	1906	0.0000E+00	0.0000E+00	0.0000E+00
R-marrow	1907	0.0000E+00	0.0000E+00	0.0000E+00
R-marrow	1908	0.0000E+00	0.0000E+00	0.0000E+00
R-marrow	1909	0.0000E+00	0.0000E+00	0.0000E+00
R-marrow	1910	0.0000E+00	0.0000E+00	0.0000E+00
R-marrow	1911	0.0000E+00	0.0000E+00	0.0000E+00
R-marrow	1912	0.0000E+00	0.0000E+00	0.0000E+00
R-marrow	1913	0.0000E+00	0.0000E+00	0.0000E+00
R-marrow	1914	0.0000E+00	0.0000E+00	0.0000E+00
R-marrow	1915	0.0000E+00	0.0000E+00	0.0000E+00
R-marrow	1916	0.0000E+00	0.0000E+00	0.0000E+00
R-marrow	1917	0.0000E+00	0.0000E+00	0.0000E+00
R-marrow	1918	0.0000E+00	0.0000E+00	0.0000E+00
R-marrow	1919	0.0000E+00	0.0000E+00	0.0000E+00

OK

Male and female equivalent organ doses for each intake regime are shown: both the 50-year committed dose (table on the left) and the annual contribution (table on the right).

Equivalent doses, Sv

Total | IR 1 | IR 2 | IR 3 | IR 4 | IR 5 | IR 6 | IR 7 | IR 8 | IR 9 | IR 10 | IR 11 | IR 12 | IR 13 | IR 14 | IR 15 | IR 16 | IR 17 | IR 18 | IR 19 | IR 20 |

Intake for this IR 1.0000E+00 (Bq, acute) Effective dose coefficient (Sv/Bq) 4.1E-08

Effective dose (Sv) 4.12E-08

Total equivalent doses (Sv) for this IR Annual equivalent doses (Sv) for this IR

	Male	Female
R-marrow	3.21E-10	4.12E-10
Colon	1.16E-10	1.32E-10
Lungs	2.98E-07	3.18E-07
St-stem	9.66E-11	1.01E-10
Breast	3.45E-11	3.86E-11
Ovaries	0.00E+00	1.03E-10
Testes	7.06E-11	0.00E+00
UB-wall	3.34E-11	4.65E-11
Oesophagus	6.30E-11	7.44E-11
Liver	5.42E-10	7.01E-10
Thyroid	4.55E-11	5.59E-11
EndostBS	2.04E-09	2.66E-09
Brain	3.47E-11	4.09E-11
S-glands	3.43E-11	4.22E-11
Skin	6.39E-11	9.01E-11
Adrenals	5.57E-11	6.28E-11
ET	4.07E-07	4.71E-07
GB-wall	4.85E-11	4.35E-11
Ht-wall	5.31E-11	6.57E-11

	Year	Male	Female
R-marrow	1901	3.2122E-10	4.1230E-10
R-marrow	1902	0.0000E+00	0.0000E+00
R-marrow	1903	0.0000E+00	0.0000E+00
R-marrow	1904	0.0000E+00	0.0000E+00
R-marrow	1905	0.0000E+00	0.0000E+00
R-marrow	1906	0.0000E+00	0.0000E+00
R-marrow	1907	0.0000E+00	0.0000E+00
R-marrow	1908	0.0000E+00	0.0000E+00
R-marrow	1909	0.0000E+00	0.0000E+00
R-marrow	1910	0.0000E+00	0.0000E+00
R-marrow	1911	0.0000E+00	0.0000E+00
R-marrow	1912	0.0000E+00	0.0000E+00
R-marrow	1913	0.0000E+00	0.0000E+00
R-marrow	1914	0.0000E+00	0.0000E+00
R-marrow	1915	0.0000E+00	0.0000E+00
R-marrow	1916	0.0000E+00	0.0000E+00
R-marrow	1917	0.0000E+00	0.0000E+00
R-marrow	1918	0.0000E+00	0.0000E+00
R-marrow	1919	0.0000E+00	0.0000E+00

OK



Male and female absorbed doses are shown for each organ and for each calendar year in the period specified by the user, as contributions from low and high LET radiation and neutrons. The table shows the total dose and the contribution from each intake regime. Doses can be ordered either by year or by organ.

## Wound model

In addition to exposure via inhalation, ingestion and injection, Taurus Advanced enables the user to also analyse cases of wound radionuclide-contamination.

Intakes from contaminated wounds are treated as special cases of injection and the user can select one of the seven predefined NCRP Wound categories. [National Council on Radiation Protection and Measurements Report No. 156, (2006).]

Activity measurements of the wound-site can also be added and used to estimate intakes.



## Linked intake regimes

Taurus enables the user to deal with up to 20 separate intake regimes simultaneously. Each regime is characterised by its specific exposure route (inhalation, ingestion, ...), absorption parameters (in the respiratory and alimentary tract), by the acute or chronic nature of the exposure and the corresponding time or time-interval of exposure.

	LR	LRfrac	Dep
1	A	0.70000	5.0 um AMAD
2	A	0.30000	5.0 um AMAD
3	B	0.50000	5.0 um AMAD
4	B	0.50000	5.0 um AMAD
5	C	1.0000	5.0 um AMAD

By default, the intake regimes are treated as independent, i.e., for a retrospective calculation the contribution to the total intake (Bq) of each intake regime is calculated as an independent contribution.

The concept of 'linked intake regimes' is particularly useful in retrospective calculations when the total intake is unknown but the relative contribution of each intake regime in a 'linked group' is known.

## Information on goodness-of-fit

Bioassay	N	ChiSquare	Probability
Total body	6	1.154E+01	3.939E-02
24h Urine	5	1.845E+00	7.759E-01

The result of a chi-square test and an autocorrelation test are shown, as well as diagnostic information for each of the bioassay sets used in the maximum-likelihood fitting.

# Bayesian analysis tool

After completing a retrospective calculation, the user can calculate the posterior probability distribution and summary statistics (e.g., mean, standard deviation) of the intake(s) and of the total effective dose providing information on intake prior distribution (Uniform, logUniform, Normal and LogNormal choices are available) using the importance sampling method.

**Max-Likelihood results**

IR	I (Bq)
A	1.252
B	5.063

Total effective dose (Sv) **1.24E-07**

Total ChiSquare **9.2029**

Degrees of freedom **58**

Save Report

Close

**Input**

**Intake sampling distribution**

IR	Distribution	From	To	Bq
A	Uniform	0.0000	3.0000	
B	Uniform	3.0000	7.0000	

50 Number of grid points    50 Number of samples

**Intake prior distribution**

IR	Distribution	From	To	Bq
A	Uniform	0.0000	3.0000	
B	Uniform	3.0000	7.0000	

Same as sampling distribution

**Results**

**Intake (Bq) summary statistics and posterior distribution**

IR	Plot	Mean	SD	Mode	Median	2.5% PI	97.5% PI
A	<input checked="" type="checkbox"/>	1.281	0.2314	1.230	1.271	0.8540	1.764
B	<input checked="" type="checkbox"/>	5.048	0.2990	5.040	5.049	4.456	5.631

Plot 1D posterior  
Plot 2D posterior

IR1	IR2	Correlation c.
A	B	-0.76

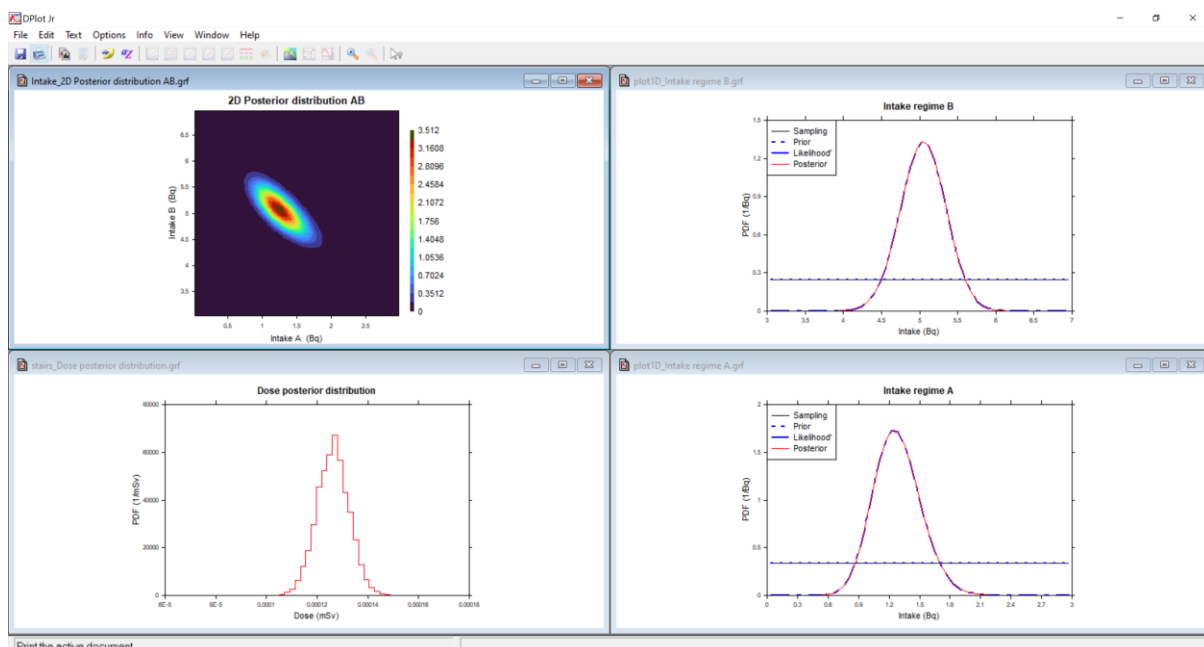
**Effective dose (Sv) summary statistics and posterior distribution**

Mean	SD	Mode	Median	2.5% PI	97.5% PI
1.24E-07	7.09E-09	1.26E-07	1.24E-07	1.12E-07	1.36E-07

Plot posterior

Model Evidence **2.2855E+06**

Plots of probability distributions (1D and 2D) are shown for intakes and for the total effective dose.



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## Methodology and computations

The Taurus software package performs intake and dose calculations for internal radiological contamination from occupational exposures, for acute or chronic intakes by inhalation, ingestion, or injection into blood.

Taurus implements the 2007 Recommendations issued in ICRP Publication 103 (ICRP, 2007) and applies the methodologies for dose calculation described in ICRP Publication 130 (ICRP, 2015) and 133 (ICRP, 2016). The new methodology and new biokinetic and dosimetric models used in the Occupational Intakes of Radionuclides (OIR) series of reports, ICRP 130, 134, 137, 141 and 151 (ICRP 2015, 2016b, 2017, 2019, 2022), supersede those used for the calculation of doses to Workers published in ICRP 68 (ICRP, 1994).

### Biokinetic and dosimetric calculations: PLEIADES

The biokinetic and dosimetric calculations in Taurus are performed by the internal dosimetry computer code PLEIADES - Program for LinEAr Internal Age-dependent DosES (Fell et al, 2007), written in Fortran 90 and developed at UK Health Security Agency's Radiation, Chemical and Environmental Hazards Directorate, UK.

#### Biokinetic calculations

Biokinetic compartment models are used to calculate the distribution of radioactivity within body tissue as a function of time following internal contamination, via inhalation, ingestion or injection into blood. The mathematical problem is defined by a set of ordinary differential equations, which are determined by an input function describing the exposure (route and duration of the intake) and by the 'biokinetic matrix' constructed with all the relevant biokinetic transfer rates and the nuclear decay data for the contaminant.

The structure and the transfer rates of the biokinetic models (respiratory, alimentary and systemic models) are published in the OIR series of reports and the radioactive decay data in ICRP Publication 107 (ICRP, 2008).

The solutions to the biokinetic equations are computed by PLEIADES in terms of the eigenvalues and eigenvectors of the biokinetic matrix and by exploiting the particular block structure of the matrix (Fell et al., 2007). PLEIADES solves the eigenvalue problems and related computations by using the LAPACK (Linear Algebra PACKAGE) library (Anderson et al., 1998) and its associated BLAS (Basic Linear Algebra Subroutines) library.

The 'eigenvalue-eigenvector' solutions to the biokinetic equations take then the familiar form of a sum of exponentials and are used to calculate the activity and the number of transformations (time-integrated activity) over any period of time in body tissues and organs.

#### Dosimetric calculations

Dosimetric models are used to calculate the deposition of energy in 'target' organs/tissues for transformations occurring in the 'source' organ/tissues as determined from the biokinetic calculations.

The information and values for energies and emissions yields of radionuclides and for the specific absorbed fractions (SAFs) used by PLEIADES are published in ICRP 107 and ICRP 133 respectively.

The radiation weighted 'S coefficients', or equivalently the Specific Effective Energies (SEEs), are calculated in PLEIADES from the published SAFs and nuclear decay data using cubic spline interpolations routines from the PCHIP library (Fritsch, 1993).

Committed equivalent dose in target regions and committed effective doses are then calculated using the radiation and tissue weighted factors published in ICRP Publication 60 and 103.

#### Bioassay predictions

The bioassay predictions are based on the biokinetic calculations. The predicted activity in organs or tissues is calculated as the sum of the activity in the model compartments assigned to that organ or tissue plus the activity in blood contained in the organ.

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## Deposition and absorption parameters for radon progeny calculations

Calculations for intakes of radon progenies

- Rn-222 (radon): Po-218, Pb-214 and Bi-214;
- Rn-220 (thoron): Pb-212 and Bi-212

can also be performed assuming reference values for exposure scenarios 'Indoor workplace', 'Mine' and 'Tourist cave' as described in the Radon chapter in ICRP Publication 137 (OIR Part 3).

Extra particle sizes are available on the drop-down menu, at the bottom of the list, when the selected nuclide is one of progeny nuclides of radon (Rn-222) or thoron (Rn-220).

Taurus

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Input

Reference

Deposition parameters

gch\_ro\_spaces

Nuclide

Po-218 3.10m

Systemic biokinetics

Alimentary tract

Respiratory

ICRP OIR series defaults

ICRP OIR series defaults

ICRP OIR series defaults

Lightwork

5.0 microns AMAD

6.0 microns AMAD

6.0 microns AMAD

7.0 microns AMAD

8.0 microns AMAD

9.0 microns AMAD

10.0 microns AMAD

20.0 microns AMAD

0.001 microns Rn\_p

0.08 microns Rn\_p

0.2 microns Rn\_p

0.250 microns Rn\_p

Each selection, e.g. '0.001 microns Rn\_p', identifies uniquely one of the unattached or attached modes for the exposure scenarios 'Indoor workplace', 'Mine' or 'Tourist cave'. The tables below summarise the main aerosol characteristics corresponding to each option shown on the menu. See paragraphs A77-A78 and Tables A5 and A7 (pages 470-472) in 'Annex A' on Radon in ICRP Publication 137 (OIR Part 3).

### Aerosol characteristics in the respiratory tract for radon progeny (Rn-222)

Exposure scenario	Mode	AMTD (m)
0.001 microns Rn_p	Indoor workplace	u 1
0.06 microns Rn_p	Indoor workplace	n 60
0.5 microns Rn_p	Indoor workplace	a 500
0.250 microns Rn_p	Mine	a 250
0.2 microns Rn_p	Tourist cave	a 200

u, unattached mode; n, nucleation mode; a, accumulation mode.

### Aerosol characteristics in the respiratory tract for thoron progeny (Rn-220)

Exposure scenario	Mode	AMTD (m)
0.001 microns Rn_p	Indoor workplace	u 1
0.06 microns Rn_p	Indoor workplace	n 80
0.4 microns Rn_p	Indoor workplace	a 400
0.250 microns Rn_p	Mine	a 250

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