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| “Approach for Estimating Exposures and Incremental Health Effects from Lead due to Renovation, Repair, and Painting Activities in Public and Commercial Buildings”  Reference Guide for Running Leggett Model Version 5 | |
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**Running Leggett Model Version 5**

# Extracting and Running the Model

The “Approach for Estimating Exposures and Incremental Health Effects from Lead due to Renovation, Repair, and Painting Activities in Public and Commercial Buildings” (Approach) uses a new Leggett model, version 5. This document provides information about how to extract and run the Leggett model.

The model and all supporting files are posted in a zip file which can be located at the following website.

<http://www2.epa.gov/lead/approach-estimating-exposures-and-incremental-health-effects-lead-due-renovation-repair-and>

The model itself is a 32-bit executable that will work on either 32-bit or 64-bit Windows machines. The model (ICRPv005d.exe) pulls inputs from a file called “POUNDS.DAT”, and outputs are in a file named “TEMP.DAT”. The code itself is also provided for reference (“ICRPv005d.FOR”). It can only be changed if the user has a compiler they can use to recompile the code.

To run the model, double clicking the ICRPv005d.exe file will run the model using whatever inputs are in the POUNDS.DAT file in the same directory. The outputs are then in the TEMP.DAT file.

If you receive an error, it is best to open up a command window in windows by going to All Programs -> Accessories -> Command Prompt. From there, navigate to the folder where the model is saved and then type “ICRPv005d.exe” at the command line. The errors will then be listed in the command window.

To facilitate building input files and plotting the results, EPA has also developed an “Excel Wrapper” tool. This tool allows the user to specify a time series of exposure values in Excel, build the Leggett input file, run the model, and import the results. This tool is called “Leggett\_Tool.xlsx” and accompanies the Leggett model in the zip file. A “Readme” tab in the Excel file gives instructions on using the tool. Please note, to use the tool, the user needs to understand how the Leggett model handles time steps and run length in the input file (see “Exposure Inputs” section below) and how variables are chosen for the output file (see “Output File” section below).

The remainder of the document discusses the structure of the input and output files so that the user can manipulate and analyze these at-will.

# The Input File

The input file is organized as a series of line inputs that are numbered. In general, there are two types of inputs:

1. Those affecting the timing and nature of exposure (Inputs 1-12) and
2. Those affecting the internal biokinetics (Inputs 13-53).

The exposure inputs (1) were changed for each simulation to match the scenario being modeled. The biokinetic inputs (2) were adjusted during the model evaluation stage but were not changed during the Monte Carlo modeling. This reference guide covers the exposure inputs in greater detail and provides an overview of the structure of the biokinetic inputs.

Exposure Inputs

The exposure inputs cover the timing of exposure and can be changed to model a wide variety of exposure scenarios. The table below provides a description of the inputs as well as an example. In the simulations performed in the Monte Carlo model and for model calibration, the background intake rates were implemented as a “direct to blood” intake while the renovation-related intakes were inhalation and/or ingestion.

**Table 1. A list of the Exposure Inputs with Description**

| **#** | **Example Values** | **Model Description** | **Additional Description** |
| --- | --- | --- | --- |
| 1 | 0.0 | Template with 8 time periods and revised bone metabolism 3/15/2002 | The value corresponds to the starting age in the simulation. |
| 2 | 1,0,3650,1569.5 | 2 - See lines 60-64 for measured values and scale factor; NDELT,DELT0,NCYCLE,ENDDAY | These provide the time steps for the model.  NDELT: The number of times the time step length will change during the simulation  NDELT0: The time step length in days \*if\* it doesn’t change during the simulation (i.e., NDELT = 1)  NCYCLE: The number of time steps in the simulation  ENDDAY: The final day in the simulation. |
| 3 | 0.5 | 3 DELTi; CALCULATIONS FIRST BASED ON STEP LENGTHS DELT1, THEN DELT2, ETC | DELTi: The time step lengths in days for each time step, if NDELT is greater than 1. |
| 4 | 3650 | 4 ICYCi; USE TIME STEP DELT1 UP TO STEP ICYC1, DELT2 UP TO ICYC2, ETC | ICYCi: The day when the time step length changes, if NDELT is greater than 1. |
| 5 | 2 | 5 WRITE TO file and SCREEN ONLY ON THESE STEPS (E.G., EVERY 100TH TIME STEP) | How many times the output is saved. The model is run every time step, but you can elect to save the output only every few time steps. |
| 6 | 21,32,33,22,23 | 6 FIVE SELECTED OUTPUTS 21,1,2,29,22-21,10,7,8,9-21,4,5,6,13-21,11,12,14,13-15,16,17,18,19 | The outputs you want to save in the output file. See Table 2 for a list of the outputs available. |
| 7 | 3,2,0 | 7 MODE OF INTAKE; SWITCH FOR ACUTE/CHRONIC; SWITCH FOR MANUAL INPUT (1) | Mode of intake: 0 = direct to blood only; 1 = inhalation only; 2 = ingestion only; 3 = all routes  Switch for Acute/Chronic: Leave at 2 for chronic  Switch for Manual Input: 0 for no manual input |
| 8 | 23 | 8 NCHRON, TIME STEPS IN CHRONIC INTAKE FUNCTION (UP TO 50) | The number of different exposure values across the length of the simulation. |
| 9 | 7,14,21,28,35,42,49,56,63,70,84,98,112,126,140,154,168,182,196,210,224,238,1820 | 9 ENDPT, ENDPOINTS OF THE CHRONIC INTAKE TIME STEPS | The day when the intake values change from one to the next (number of values must equal NCHRON). |
| 10 | 5.,5.,5.,5.,5.,5.,5.,5.,5.,5.,5.,5.,5.,5.,5.,5.,5.,5.,5.,5.,5.,5.,5. | 10 UP TO 50 CHRONIC INTAKE RATES DIRECTLY TO BLD ON STEPS | The intake rates corresponding to exposure directly to blood (number of values must equal NCHRON). |
| 11 | 2.0,0.0,0.0,0.0,0.0,0.0,0.0,0.0,0.0,0.0,0.0,0.0,0.0,0.0,0.0,0.0,0.0,0.0,0.0,0.0,0.0,0.0,0.0 | 11 UP TO 50 CHRONIC LUNG DEPOSITION RATES (PER DAY) | The inhalation intake rates (number of values must equal NCHRON). |
| 12 | 2.0,2.0,2.0,2.0,2.0,0.0,0.0,0.0,0.0,0.0,0.0,0.0,0.0,0.0,0.0,0.0,0.0,0.0,0.0,0.0,0.0,0.0,0.0 | 12 UP TO 50 CHRONIC INGESTION INTAKE RATES (PER DAY) | The ingestion intake rates (number of values must equal NCHRON). |

The available outputs are number-coded and up to five can be selected (input line 6). Table 2 provides a key of the available outputs.

**Table 2. Available Output Variables**

| **#** | **Output Name** | **Output Description** | **Units** |
| --- | --- | --- | --- |
| 1 | YPLAS | Mass of lead in plasma | g |
| 2 | YRBC | Mass of lead in red blood cells | g |
| 3 | YBLUD | Mass of lead in blood | g |
| 4 | YSKEL | Mass of lead in skeleton | g |
| 5 | YCORT | Mass of lead in cortical bone | g |
| 6 | YTRAB | Mass of lead in trabecular bone | g |
| 7 | YLIVR | Mass of lead in liver | g |
| 8 | YKDNE | Mass of lead in kidney | g |
| 9 | YSOFT | Mass of lead in soft tissue | g |
| 10 | YBRAN | Mass of lead in brain | g |
| 11 | YURIN | Mass of lead in urine | g |
| 12 | YFECE | Mass of lead in feces | g |
| 13 | TBODY2 | Total mass of lead in body | g |
| 14 | TOTEXC | Total mass of lead excreted | g |
| 15 | BONFRC | Fraction of lead in bone | none |
| 16 | BRNFRC | Fraction of lead in brain | none |
| 17 | HEPFRC | Fraction of lead in liver | none |
| 18 | BLDFRC | Fraction of lead in blood | none |
| 19 | RENFRC | Fraction of lead in kidney | none |
| 20 | OTHFRC | Fraction of lead in other tissues | none |
| 21 | BLCONC | Blood lead concentration | g/dL |
| 22 | RBCONC | Red blood cell lead concentration | g/dL |
| 23 | RENCON | Kidney lead concentration | g/g |
| 24 | CRTCON | Cortical bone lead concentration | g/g |
| 25 | TRBCON | Trabecular bone lead concentration | g/g |
| 26 | ASHCON | Ash bone lead concentration | g/g |
| 27 | CLEAR | Total amount of plasma lead cleared via urine | g |
| 28 | BCLEAR | Total amount of blood lead cleared via urine | g |
| 29 | PCENT | Fraction of blood lead that is in plasma | none |
| 30 | YLUNG | Mass of lead in the lung | g |
| 31 | *none* | Fraction of blood lead cleared | none |
| 32 | CRTCONBM | Cortical bone mineral density lead concentration | g/g |
| 33 | TRBCONBM | Trabecular bone mineral density lead concentration | g/g |
| 34 | UPTAKEGI | Uptake in the GI track | g |
| 35 | UPTAKERI | Uptake via inhalation | g |
| 36 | UPTAKE | Total uptake | g |

Biokinetic Inputs

The biokinetic inputs make up the rest of the inputs in the model. These inputs represent the parameters revisited in spring 2014 and updated to form version 5 of the model. In many cases, the new values appear as inputs and can be adjusted by the user. In a few cases, the parameter went from being age-independent to age-dependent. For those, the values in the input file are dummy values and the values are hard coded in the code. These cannot be changed unless the user can then recompile the code and generate a new executable file. These inputs include inputs 47 and 51 (deposition fraction in red blood cells and amount of red blood cells and plasma in an adult male), as noted in the input file.

The biokinetic inputs are set up to change at defined ages. In the current input file and model, there are 14 ages where the inputs can change:

0.,0.274,1.,5.,10.,15.,18.,24.,30.,40.,45.,55.,65., and 75. years old.

The remaining inputs then have values for each of these age groups. For example, a line such as:

8\*1.0, 6\*0.8

implies “use 1.0 for the first eight age ranges and 0.8 for the last six age ranges”. The user can change the values for any or all age groups in the input file.

The model also contains a switch for whether to use the linear or nonlinear RBC equation. This occurs on line 17 in the input file. The first parameter is the switch (0 = linear, 1 = nonlinear) and the other three parameters are the nonlinear equation parameters.

# The Output File

The output file is called “TEMP.dat” and will appear in the same folder as the input file after the model successfully runs. Always check the date stamp of the output file after running the model to make sure the file updated successfully; otherwise, the model likely encountered an error. The output file does not have headers, so it is important to understand what is in each column:

|  |  |
| --- | --- |
| **Column** | **Variable** |
| 1 | The time in the simulation in years. |
| 2 | The total mass of lead in the body in g. |
| 3 | The data corresponding to the *first* variable chosen on input line 6 (blood lead in the example input file). |
| 4 | The data corresponding to the *second* variable chosen on input line 6 (cortical bone density concentration in the example input file). |
| 5 | The data corresponding to the *third* variable chosen on input line 6 (trabecular bone density concentration in the example input file). |
| 6 | The data corresponding to the *fourth* variable chosen on input line 6 (red blood cell concentration in the example input file). |
| 7 | The data corresponding to the *fifth* variable chosen on input line 6 (kidney concentration in the example input file). |

The data can be imported into Excel and plotted using Excel’s Data -> Get External Data -> From Text functionality or you can use the Leggett\_Tool.xslx tool to import the data.

# The Estimation of the Background Intake Values

The final set of files in the zip file package are the Excel files used to estimate the background intake rates for a person born in each year that best match the available NHANES data for that age group, as described in the Approach Appendices. Six different age ranges were defined, and starting estimates for the background lead intake were derived by assuming 1) the earliest exposure was 100 ug/day and 2) that the ratio of the exposure in other years scaled similarly to the ratio between the NHANES mean blood lead values in those years.

In each file, the “RUN” tab contains the inputs. The initial estimate for the age group is shown in Column F, while the available NHANES data for different years is shown in Column E, rows 22 and below. The Excel file derives the best factor to multiply each of the initial estimates by to best fit the NHANES data, and the rest of the tab contains formulas that build the inputs needed for the Leggett input file. Pushing the “RUN” button will run the Leggett model multiple times until the mean square error between the predicted and actual mean blood leads is minimized. The “MIN” tab shows the mean square error (y-axis) for different multiplicative factors (x-axis), and the tool selects the factor where the mean square error is at a minimum. The factor is then saved for each age in the age range on the “OUTPUT” tab.

There are seven excel files that characterize background blood lead values by year.

1. Leggett-background-1930-1954-mult.xlsb
2. Leggett-background-1955-1966-mult.xlsb
3. Leggett-background-1967-1976-mult.xlsb
4. Leggett-background-1977-1986-mult.xlsb
5. Leggett-background-1987-1996-mult.xlsb
6. Leggett-background-1996-2011-mult.xlsb
7. Leggett-background-2012-2014-mult.xlsb

To see the full results of this analysis, the “Leggett-background-aggregate.xlsx” file contains all of the NHANES data and the blood leads corresponding to the fit intakes. On the “graph” tab, different birth years can be selected in cell D2. The graph then shows both the actual NHANES data and the fit blood leads from the Leggett model for that birth year.