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**TRANSMITTAL OF SAMPLE CALCULATIONS FOR DEVELOPING  
PRELIMINARY REMEDIATION GOALS (PRGS) FOR BERYLLIUM**

07/12/94

DOE-2078-94  
DOE-FN        EPA  
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LETTER



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**JUL 12 1994**  
DOE-2078-94

Mr. James A. Saric, Remedial Project Manager  
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77 W. Jackson Boulevard  
Chicago, Illinois 60604-3590

Mr. Tom Schneider, Project Manager  
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Dear Mr. Saric and Mr. Schneider:

**TRANSMITTAL OF SAMPLE CALCULATIONS FOR DEVELOPING PRELIMINARY REMEDIATION GOALS (PRGs) FOR BERYLLIUM**

As discussed at the meeting between the United States Environmental Protection Agency (USEPA) and the Department of Energy (DOE) on July 7, 1994, in Chicago, the following sample calculations for developing preliminary remediation goals (PRGs) for beryllium are being transmitted for your consideration. The calculations illustrate the key aspects of the methodology required by the USEPA Environmental Criteria and Assessment Office (ECAO). Based on our discussions last week special attention should be applied toward the absorption factors through the skin ( $ABS_{sk}$ ) and the gastrointestinal tract ( $GI_{abs}$ ). As a result of the direction from USEPA Region-V the calculations for the contribution to risk from the dermal pathway were calculated using and absorption factor of 0.1% instead of 1.0% as specified in the May 24, 1994 Memorandum from ECAO. The results of this change are positive in that the overall contribution from the dermal pathway is reduced as anticipated, however the reduction is small and the total contribution is still on the order of 76% for the dermal pathway.

At the meeting some discussion was provided concerning the absorption factor for the oral pathway. The DOE would appreciate consideration of a change in the oral absorption factor from 1.0% to 10%. This magnitude of change would yield PRGs and overall risk numbers that are more commensurate with the available data concerning the dermal pathway. In light of the difficulties with the dermal pathway for beryllium the DOE is requesting to use an approach that would assume that the dermal pathway be considered as toxic as the oral pathway to limit the overall contribution of the dermal pathway.

If you have any questions concerning the above please contact Randy C. Janke at (513) 648-3123 if there are any additional questions regarding this submittal.

Sincerely,

*for*   
Jack R. Craig

Fernald Remedial Action  
Project Manager

FN:RC Janke

Enclosures: As Stated

cc w/enc:

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## EXAMPLE CALCULATIONS FOR BERYLLIUM

### 1.0 EXAMPLE CALCULATIONS FOR DERMAL CONTACT AND INCIDENTAL INGESTION OF SOIL BASED ON DEFAULT PARAMETER VALUES

This section presents example calculations for calculating the incremental lifetime cancer risk from exposure to beryllium in soils. This example uses default exposure parameter values used for the FEMP for both the OU4 and OU1 RI/FSs.

#### 1.1 Dermal Contact with Beryllium in Soil

An incremental lifetime cancer risk from dermal contact with beryllium in soil is calculated by first calculating a dermally applied dose with the equation:

$$DAD_{Be} = \frac{(C_{S_{Be}}) (SA) (AF) (ABS) (EF) (ED) (CF)}{(BW) (AT)} \quad (1)$$

where:  $DAD_{Be}$  = Dermally absorbed dose for beryllium from contact with soil (mg/Kg/day);  
 $C_{S_{Be}}$  = Concentration of beryllium in soil (mg/Kg);  
SA = Surface area for dermal contact (cm<sup>2</sup>/event);  
AF = Soil-adherence factor to skin (mg/cm<sup>2</sup>);  
 $ABS_{Be}$  = Soil dermal absorption factor (unitless);  
EF = Exposure frequency (events/yr);  
ED = Exposure duration (years);  
CF = Unit conversion factor (10<sup>-6</sup> Kg/mg);  
BW = Body weight (Kg); and  
AT = Averaging time (days).

Default values for these parameters are as follows. For illustration purposes, the background concentration for beryllium in surface soils will be used for this example.

$DAD_{Be}$  = [calculated below] (mg/Kg/day);  
 $C_{S_{Be}}$  = 0.6 mg/Kg [representative background concentration for beryllium in surface soils];  
SA = 5,750 cm<sup>2</sup>/event [25% of 95<sup>th</sup> percentile value for body surface area of 23,000 cm<sup>2</sup> from Dermal Assessment Guidance, (EPA 1992)];  
AF = 1 mg/cm<sup>2</sup> [maximum of range from 0.2 to 1 from Dermal Assessment Guidance, (EPA 1992)];  
 $ABS_{Be}$  = 0.01 (unitless) [value for beryllium from ECAO, memo from Joan Dollarhide to Pat VanLeeuwen, July 21, 1993];  
EF = 350 events/yr [from Risk Assessment Work Plan Addendum (DOE, 1992)];  
ED = 70 years [from Risk Assessment Work Plan Addendum (DOE, 1992)];  
CF = 10<sup>-6</sup> Kg/mg;  
BW = 70 Kg; [default value for adult from Superfund Risk Assessment Guidance (EPA

AT = 1989)] and  
 25,550 days [default value for assessing incremental lifetime cancer risk from exposure carcinogenic compounds assuming 70 year lifetime from Superfund Risk Assessment Guidance (EPA 1989)].

Substitution of these default parameters into Equation 1 gives a  $DAD_{Be}$  as follows:

$$DAD_{Be} = \frac{(0.6 \text{ mg/Kg}) (5,750 \text{ cm}^2) (1 \text{ mg/cm}^2) (0.01) (350 \text{ d/yr}) (70 \text{ yrs}) (10^{-6})}{(70 \text{ Kg}) (25,550 \text{ d})} \quad (2)$$

or:

$$DAD_{Be} = 4.73 \times 10^{-7} \quad (3)$$

The incremental lifetime cancer risk (ILCR) from exposure to beryllium via dermal contact is calculated with the equation:

$$ILCR_{der_{Be}} = DAD_{Be} * CSF_{der_{Be}} \quad (4)$$

where:  $CSF_{der_{Be}}$  = Cancer slope factor for beryllium for dermal contact based on absorbed dose (mg/Kg/day)<sup>-1</sup>. This dermal cancer slope factor must be calculated from an oral CSF. For constituents that the cancer slope factor is based on an absorbed dose, no adjustment on the oral CSF is needed for the dermal CSF. For those constituents where the oral CSF is based on an administered dose, the dermal slope factor is calculated based the following equation:

$$CSF_{der} = \frac{CSF_{oral}}{GI_{abs}}$$

where:  $CSF_{oral}$  = Oral cancer slope factor (mg/Kg/day)<sup>-1</sup>; and  
 $GI_{ABS}$  = Gastrointestinal absorption factor (unitless).

The oral CSF for beryllium was based on a drinking water study on male rats (ATSDR, 1991), thus an adjustment should be made from an administered to absorbed dose. ECAO recommended a  $GI_{ABS}$  of 0.01 for beryllium (memo from Joan Dollarhide to Pat VanLeeuwen, July 21, 1993). Thus, by substituting the oral CSF of 4.3 (EPA [IRIS] 1994) and a  $GI_{ABS}$  of 0.01 into Equation 5, a dermal slope factor of 430 is obtained. Therefore, the ILCR from dermal exposure to background concentrations of beryllium in surface soils is calculated as:

$$ILCR_{der\ Be} = 4.73 \times 10^{-7} \text{ (mg/Kg/day)} * 430 \text{ (mg/Kg/day)}^{-1} \quad (6)$$

or:

$$ILCR_{der\ Be} = 2.03 \times 10^{-4} \quad (7)$$

## 1.2 Incidental Ingestion from Soil

The ILCR from incidental ingestion of beryllium in surface soil is calculated by first calculating the lifetime average daily intake as follows:

$$I_{ing\ Be} = \frac{(C_{S\ Be}) (IR) (FI) (EF) (ED) (CF)}{(BW) (AT)} \quad (8)$$

where:  $I_{ing\ Be}$  = Lifetime average daily intake of beryllium from incidental ingestion of surface soil (mg/Kg/day);  
 IR = Incidental ingestion rate of soil (g/day);  
 FI = Fraction ingested from the contaminated source (unitless);  
 EF = Exposure frequency (days/yr);  
 ED = Exposure duration (years);  
 CF = Conversion factor ( $10^{-3}$  Kg/g);  
 BW = Body weight (Kg); and  
 AT = Averaging time (days).

Default values for these parameters are as follows. For illustration purposes, the background concentration for beryllium in surface soils will be used for this example.

$I_{ing\ Be}$  = [calculated below] (mg/Kg/day);  
 $C_{S\ Be}$  = 0.6 mg/Kg [representative background concentration for beryllium in surface soils];  
 IR = 0.18 g/day [value calculated for the RME farmer, Draft OU1 RI (DOE 1994)];  
 FI = 1 [assumes 100% exposure to contaminated soils from source];  
 EF = 350 events/yr [from Risk Assessment Work Plan Addendum (DOE, 1992)];  
 ED = 70 years [from Risk Assessment Work Plan Addendum (DOE, 1992)];  
 CF =  $10^{-3}$  Kg/g;  
 BW = 70 Kg; [default value for adult from Superfund Risk Assessment Guidance (EPA 1989)] and  
 AT = 25,550 days [default value for assessing incremental lifetime cancer risk from exposure carcinogenic compounds assuming 70 year lifetime from Superfund Risk Assessment Guidance (EPA 1989)].

Substitution of these default parameters into Equation 8 gives an intake rate from incidental ingestion of soil ( $I_{ing\ Be}$ ) as follows:

$$I_{ing_{Be}} = \frac{(0.6 \text{ mg/Kg}) (0.18 \text{ g/d}) (1) (350 \text{ d/yr}) (70 \text{ yrs}) (10^{-3} \text{ Kg/g})}{(70 \text{ Kg}) (25,550 \text{ d})} \quad (9)$$

or:

$$I_{ing_{Be}} = 1.48 \times 10^{-6} \quad (10)$$

The incremental lifetime cancer risk (ILCR) from exposure to beryllium via incidental ingestion of soil is calculated with the equation:

$$ILCR_{ing_{Be}} = I_{ing_{Be}} * CSF_{oral_{Be}} \quad (11)$$

Substituting the proper values gives:

$$ILCR_{der_{Be}} = 1.48 \times 10^{-6} (\text{mg/Kg/day}) * 4.3 (\text{mg/Kg/day})^{-1} \quad (12)$$

or:

$$ILCR_{ing_{Be}} = 6.36 \times 10^{-6} \quad (13)$$

Thus, a concentration of 0.6 mg/Kg of beryllium in surface soils (background) yields an ILCR for dermal contact of  $2.03 \times 10^{-4}$ , an ILCR of  $6.36 \times 10^{-6}$  for incidental ingestion, for a combined total of  $2.1 \times 10^{-4}$ . A comparison of the ILCR from dermal contact to the ILCR from incidental ingestion suggests that the dermal pathway contributes approximately 97% to the total ILCR.

## 2.0 EXAMPLE CALCULATIONS FOR DERMAL CONTACT AND INCIDENTAL INGESTION OF SOIL BASED ON PROPOSED PARAMETER VALUES

This section presents example calculations for calculating the ILCR from exposure to beryllium in soils using proposed parameter value for the dermal absorption rate for beryllium from soil.

### 2.1 Dermal Contact with Beryllium in Soil

An incremental lifetime cancer risk from dermal contact with beryllium in soil is calculated using Equation 1. Default values for these parameters are as follows. However, the value for  $ABS_{Be}$  was changed from 0.01 (1%) to 0.001 (0.1%), according to an agreement made at a meeting between DOE-FN and EPA-Region V on July 7, 1994. Parameter values used for this calculation are:

DAD <sub>Be</sub>	=	[calculated below] (mg/Kg/day);
Cs <sub>Be</sub>	=	0.6 mg/Kg [representative background concentration for beryllium in surface soils];
SA	=	5,750 cm <sup>2</sup> /event [25% of 95 <sup>th</sup> percentile value for body surface area of 23,000 cm <sup>2</sup> from Dermal Assessment Guidance, (EPA 1992)];
AF	=	1 mg/cm <sup>2</sup> [maximum of range from 0.2 to 1 from Dermal Assessment Guidance, (EPA 1992)];
ABS <sub>Be</sub>	=	0.001 (unitless) [proposed value for beryllium from meeting between EPA-Region V and DOE-FN, July 7, 1994];
EF	=	350 events/yr [from Risk Assessment Work Plan Addendum (DOE, 1992)];
ED	=	70 years [from Risk Assessment Work Plan Addendum (DOE, 1992)];
CF	=	10 <sup>-6</sup> Kg/mg;
BW	=	70 Kg; [default value for adult from Superfund Risk Assessment Guidance (EPA 1989)] and
AT	=	25,550 days [default value for assessing incremental lifetime cancer risk from exposure carcinogenic compounds assuming 70 year lifetime from Superfund Risk Assessment Guidance (EPA 1989)].

Substitution of these default parameters into Equation 1 gives a DAD<sub>Be</sub> as follows:

$$DAD_{Be} = \frac{(0.6 \text{ mg/Kg}) (5,750 \text{ cm}^2) (1 \text{ mg/cm}^2) (0.001) (350 \text{ d/yr}) (70 \text{ yrs}) (10^{-6})}{(70 \text{ Kg}) (25,550 \text{ d})} \quad (14)$$

or:

$$DAD_{Be} = 4.73 \times 10^{-8} \quad (15)$$

The ILCR from exposure to beryllium via dermal contact is calculated with Equation 4. Therefore, by substituting the dermal applied dose from beryllium (DAD<sub>Be</sub>) and dermal cancer slope factor for beryllium (CSF<sub>der-Be</sub>) into Equation 4 gives an ILCR from dermal exposure (assuming background concentrations) of:

$$ILCR_{der,Be} = 4.73 \times 10^{-8} (\text{mg/Kg/day}) * 430 (\text{mg/Kg/day})^{-1} \quad (16)$$

or:

$$ILCR_{der,Be} = 2.03 \times 10^{-5} \quad (17)$$

## 2.2 Incidental Ingestion from Soil

The ILCR from incidental ingestion of beryllium in surface soil is calculated using Equations 8 to 13. DOE-FN is not proposing to use alternative parameter values for incidental ingestion of beryllium

from soil. Thus, the intake of beryllium from background concentration in soil via incidental ingestion is  $1.48 \times 10^{-6}$  with an ILCR of  $6.36 \times 10^{-6}$ .

The concentration of 0.6 mg/Kg of beryllium in surface soils (i.e., background) yields an ILCR for dermal contact of  $2.03 \times 10^{-5}$ , an ILCR of  $6.36 \times 10^{-6}$  for incidental ingestion, for a combined total of  $2.7 \times 10^{-5}$ . A comparison of the ILCR from dermal contact to the ILCR from incidental ingestion suggests that the dermal pathway contributes approximately 76% to the total ILCR using the proposed value of 0.001 for the dermal absorption rate ( $ABS_{Be}$ ).

### 3.0 SUMMARY AND CONCLUSIONS

As illustrated by the example calculations using default parameters, the dermal exposure pathway to soil for beryllium is assumed to contribute 97% to the total risk. DOE feels that this conclusion is contradictory to current knowledge regarding beryllium toxicokinetics. ECAOs literature review (memo from Joan Dollarhide to Pat VanLeeuwen, July 21, 1993) clearly states the following points:

- 1) *"It is unlikely that beryllium is absorbed through intact skin."* (page 54)
- 2) *"Because of the chemical properties of beryllium, it is unlikely that significant amounts could be absorbed through the skin."* (page 54-55)

Therefore, DOE-FN concludes that the default values proposed by ECAO do not provide results that are consistent current knowledge of beryllium absorption. The use of the proposed value of 0.001 (0.1%) for dermal absorption rate (ABS), which is a default value for metals, although reduces the significance of dermal contact with beryllium, it still appears to overestimate the significance from the dermal exposure pathway. Thus, DOE-FN proposes to evaluate the contribution to the ILCR for beryllium from the dermal exposure pathway from soil by assuming its contribution is equal to that from the oral route (i.e., incidental ingestion) until more definitive data can be obtained for this route of exposure. This method is viewed as conservative considering the carcinogenic effect under consideration are an increased incidence of tumors in male rats from ingestion of beryllium in drinking water. For this effect to occur from dermal contact, absorption across the epidermis would be required.

## References

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