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REVISED  
RISK ASSESSMENT  
BINGHAMTON STATE OFFICE BUILDING

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## Introduction

Two methods are commonly used for establishing standards or guidelines for contaminant levels in food, air or water. One method is to perform an extrapolation to low level exposure using data from a high dose carcinogenic bioassay; this procedure calculates a dose which corresponds to a given lifetime cancer risk. The second is to establish an acceptable daily intake (ADI) usually based on a no-observed effect level (NOEL) in an animal study. The polychlorinated dioxin or furan which has the most toxicologic data to use in a risk assessment is 2,3,7,8-TCDD. This compound has caused cancer in laboratory animals but the tests to date have not shown it to be genotoxic. The scientific community is divided on the proper procedures to use under these circumstances. The following risk assessments use both carcinogenic extrapolation procedures and a no-observed effect level to calculate guidelines.

## Background

This risk assessment is not intended as a review of the human health effects or available toxicologic data for polychlorinated dibenzodioxins or dibenzofurans. Several reviews already exist in the literature. [See references] This risk assessment is to provide material for the Expert Advisory Panel to discuss and make recommendations for re-entry criteria for the Binghamton State Office Building. Accounts of the fire and subsequent findings are available elsewhere.

Human exposure to dioxin-contaminated materials has resulted in chloracne, limited nerve damage, liver abnormalities and psychological disorders. Laboratory studies have shown 2,3,7,8-TCDD to be carcinogenic, embryotoxic, and teratogenic in various animal species and to affect a number of organs and systems including thyroid, liver, skin and the immunologic system. Based on a review of the literature, the no-effect level was set using long-term animal feeding studies examining oncogenic and reproductive effects.

## Risk Assessment

Normally, an ADI is not set from a NOEL for compounds which have been found to be carcinogenic. However, to date 2,3,7,8-TCDD has not been shown to be genotoxic and some scientists use a no-observed effect level to calculate guidelines under these circumstances. For 2,3,7,8-TCDD, a no-observed effect level of 1 nanogram/kg-day ( $1 \times 10^{-9}$ g/kg-day) in rats has been reported in both a three generation reproduction study [Murray, et al., 1979] and a two year oncogenic study [Kociba, et al. 1978]. An uncertainty factor of 300 was considered appropriate by the Expert Advisory Panel. The acceptable daily intake for humans would be two picogram/kg-day ( $2 \times 10^{-12}$ g/kg-day).

Following the March 29, 1982 meeting, the Expert Advisory Panel concluded, that the final re-entry criteria would be based on a maximum total daily intake of two picograms of 2,3,7,8-TCDD per kilogram-day. The average weight of 50 kilograms (based on an adult female) would be used in calculating a guideline for re-entry.

Cancer risk extrapolations have been used since the early 1960's. Once a dose-response relationship is established, an "acceptable" risk level must be assumed and the corresponding dose calculated. Mantel-Bryan [Mantel, et al., 1951] originally defined a virtually safe risk for a lifetime as  $1 \times 10^{-8}$ . Since then, other regulatory agencies have used risks in the  $1 \times 10^{-7}$  to  $1 \times 10^{-5}$  range for setting standards or guidelines [U.S. FDA, 1980 and U.S. EPA, 1980b].

Several mathematical models are available for performing cancer risk calculations. Recently the EPA has published dose-response data for 2,3,7,8-TCDD. These data and others will be used to calculate the cancer risk levels which correspond to the re-entry guideline.

### Equivalents

The toxicity of the soot expressed in terms of the 2,3,7,8-TCDD equivalents was measured by Eadon et al. (1981) by administering an aqueous suspension of the soot to guinea pigs. The toxicity of the soot, compared to that of a soot sample containing only 2,3,7,8-TCDD administered under identical conditions, was equivalent to a 2,3,7,8-TCDD concentration of 58 ppm.

For comparison purposes, a mathematical estimate of the 2,3,7,8-TCDD equivalents in the soot was also made (Eadon et al. 1982). Using the known concentration of chlorinated dioxins, furans, and biphenylenes in the soot and making certain assumptions about their toxicity as compared to 2,3,7,8-TCDD, the toxicity of the soot was calculated to be approximately 44 ppm of 2,3,7,8-TCDD equivalents. The calculated value of 44 ppm is in good agreement with the observed value of 58 ppm.

This same procedure has been applied to the air sampling results (Eadon et al., 1983). For the air samples, which had an average 2,3,7,8-TCDD content of  $0.4 \text{ pg/m}^3$ , the toxicity for the mixture of chlorinated dioxins, furans and biphenylenes was estimated to be  $14 \text{ pg/m}^3$  of 2,3,7,8-TCDD equivalents. This calculated level of  $14 \text{ pg/m}^3$  of 2,3,7,8-TCDD equivalents should be compared with the suggested guidelines for re-entry.

### Exposure - Clean-up Workers

At the present, workers are wearing protective clothing and respirators. If respirators are not used, inhalation is a possible route of exposure. (Dermal contact will not be considered since the workers will be wearing gloves and other protective clothing.) Since these workers are males, a risk assessment for this exposure only will be based on a 70 kilogram male. The maximum exposure would be for 8 hours per day, 250 days per year and 1 1/2 years. For the inhalation calculations, a respiratory volume of  $10 \text{ m}^3$  per 8 hour work day is assumed. The guidelines calculated for the clean-up crew range from a minimum of  $14 \text{ pg/m}^3$  to a maximum of  $930 \text{ pg/m}^3$  of 2,3,7,8-TCDD equivalents. (See Guideline Calculations)

## Exposure - Office Workers

Three different exposure routes are possible for workers in the Binghamton State Office Building: inhalation, ingestion and dermal absorption. The risk assessment will be based on the 50 kilogram female. The assumption that a worker would be exposed for 30 years, 250 days per year is considered to be the maximum possible duration for the exposure. For the inhalation calculations, a respiratory volume of  $10 \text{ m}^3$  is assumed for an 8 hour work day. The guidelines calculated for the office workers range from a minimum of  $10 \text{ pg/m}^3$  to a maximum of  $160 \text{ pg/m}^3$  of 2,3,7,8-TCDD equivalents. (See Guideline Calculations)

Although the Expert Advisory Panel considered inhalation the most important route of exposure, a surface guideline would be useful. To calculate a surface guideline, assumptions must be made concerning how much skin surface is exposed and how much contamination is transferred, absorbed dermally, and ingested.

Three different scenarios were used to estimate the reduction in contamination over time and to calculate the average daily exposure over the 30 year period [Kim, et al., 1982]. Scenario A assumes that the contaminant concentration remains constant during the 30 year period. In Scenario B a first order exponential decay curve is used which assumes that over 30 years contamination levels drop to one percent of the values when the building is reoccupied. Using this approach, a slightly higher concentration would be acceptable in the building when its reopened. Scenario C also employs a first order exponential decay curve, but assumes a half-life of one year for the disappearance of contaminants in the building. Scenario C has been eliminated.

### Guideline for Re-entry

The following is suggested as an appropriate methodology for deriving a guideline for re-entry.

1. One ng/kg-day is used as a "no-observed effect level" for 2,3,7,8-TCDD in rats [Murray, et al., 1979; Kociba, et al., 1978].
2. An uncertainty factor of 500 is used to obtain a daily intake for 2,3,7,8-TCDD.

$$\frac{1 \text{ ng/kg-day}}{500} = 2 \times 10^{-3} \text{ ng/kg-day} = 2 \text{ pg/kg-day} \quad (1)$$

3. For office workers, an average weight of 50 kilograms is used to obtain a daily dose for 2,3,7,8-TCDD; for the clean-up crew an average weight of 70 kilograms is used.

$$\begin{aligned} 2 \text{ pg/kg-day} \times 50 \text{ kg} &= 100 \text{ pg/day for 2,3,7,8-TCDD office workers} \\ 2 \text{ pg/kg-day} \times 70 \text{ kg} &= 140 \text{ pg/day for 2,3,7,8-TCDD clean-up crew} \end{aligned}$$

AIR

Inhalation Exposure

1. The air sampling results have been expressed in terms of 2,3,7,8-TCDD equivalents (Eadon, 1983). The same dose of 100 pg (office workers) or 140 pg (clean-up crew) of 2,3,7,8-TCDD will be used to derive a guideline for the mixture; in this case, the units will be expressed as 100 pg or 140 pg of 2,3,7,8-TCDD equivalents.
2. A breathing volume of 10m<sup>3</sup> for an average 8-hour day is used to calculate an air guideline for 2,3,7,8-TCDD equivalents.

$$\frac{100 \text{ pg}}{10 \text{ m}^3} = 10 \text{ pg/m}^3 \text{ of 2,3,7,8-TCDD equivalents (office workers) (2)}$$

$$\frac{140 \text{ pg}}{10 \text{ m}^3} = 14 \text{ pg/m}^3 \text{ of 2,3,7,8-TCDD equivalents (clean-up crew) (3)}$$

The guidelines for re-entry are based on a daily intake of 2 pg/kg-day of 2,3,7,8-equivalents and presumes a lifetime exposure. If the toxic effects are associated with cumulative lifetime dose and exposure is limited to a fraction of an individual's lifetime, then the daily intake during that period could be increased proportionately.

Office workers (250 days per year for 30 years)

$$\frac{10 \text{ pg}}{\text{m}^3} \times \frac{365}{250} = \frac{15 \text{ pg}}{\text{m}^3} \text{ of 2,3,7,8-TCDD equivalents}$$

$$\frac{15 \text{ pg}}{\text{m}^3} \times \frac{70}{30} = \frac{35 \text{ pg}}{\text{m}^3} \text{ of 2,3,7,8-TCDD equivalents}$$

Clean-up crew (250 days per year for 1.5 years)

$$\frac{14 \text{ pg}}{\text{m}^3} \times \frac{365}{250} = \frac{20 \text{ pg}}{\text{m}^3} \text{ of 2,3,7,8-TCDD equivalents}$$

$$\frac{20 \text{ pg}}{\text{m}^3} \times \frac{70}{1.5} = \frac{930 \text{ pg}}{\text{m}^3} \text{ of 2,3,7,8-TCDD equivalents}$$

- b. Using Scenario B for contamination decreasing over time, the initial concentration is calculated assuming that the average daily exposure over 30 years is  $10 \text{ pg/m}^3$  (equation 2) or  $35 \text{ pg/m}^3$  of 2,3,7,8-TCDD equivalents (equation 3). (N. Kim and J. Hawley. 1982. Risk Assessment: Binghamton State Office Building. New York State Department of Health.)

Office Workers only

$$\frac{10 \text{ pg}}{\text{m}^3} \times \frac{30}{6.4} = \frac{47 \text{ pg}}{\text{m}^3} \text{ of 2,3,7,8-TCDD equivalents}$$

$$\frac{35 \text{ pg}}{\text{m}^3} \times \frac{30}{6.4} = \frac{160 \text{ pg}}{\text{m}^3} \text{ of 2,3,7,8-TCDD equivalents}$$

Surfaces

Ingestion/Dermal Exposure

1. Surface contact is assumed to result in the transfer of contaminants to the skin as measured by a wipe test .
2. Total body surface area in square meters (S) can be estimated from a person's height in centimeters (H) and weight in kilograms (W). [DuBois, et al., 1916; Ganong, 1975; Guyton, 1976] Data from the National Center for Health Statistics "indicate that the height of a 50 kilogram female averages about 154 centimeters."

$$S = 0.007184 \times W^{0.425} \times H^{0.725}$$

$$S = 0.007184 \times 50^{0.425} \times 154^{0.725}$$

Total surface area is  $1.46 \text{ m}^2$

3. The hands account for approximately 4.5% of the total surface area.

$$1.46 \text{ m}^2 \times .045 = 0.0657 \text{ m}^2$$

4. The contaminants from 5%, 10% or 25% of the surface area of the hands is assumed to be ingested every day.

$$0.0657 \text{ m}^2 \times 0.05 = 0.0033 \text{ m}^2$$

$$0.0657 \text{ m}^2 \times 0.10 = 0.0066 \text{ m}^2$$

$$0.0657 \text{ m}^2 \times 0.25 = 0.0164 \text{ m}^2$$

5. The maximum exposed surface area for considering dermal absorption is the entire area of both arms. That surface area for a 50 kilogram female is 19% of the total body surface area or  $0.28\text{m}^2$  ( $0.19 \times 1.46\text{m}^2$ ). [Diem et al., 1970] Contact between skin and contaminated walls (or other surface) is assumed to occur for 10%, 25% or 50% of this surface area.

$$0.10 \times 0.28\text{m}^2 = 0.028\text{m}^2$$

$$0.25 \times 0.28\text{m}^2 = 0.070\text{m}^2$$

$$0.50 \times 0.28\text{m}^2 = 0.14\text{m}^2$$

6. The amount of contamination absorbed by the skin is assumed to be 1% or 10%. [Poiger et al., 1990]
7. Selecting among the assumptions outlined previously will define a surface area guideline. The maximum and minimum guidelines among all possible guidelines are calculated below.

a. Maximum guideline

Assumptions - ingest contamination from 5% of the hands' surface area ( $0.0033\text{m}^2$ )

- absorb 1% of the contamination with 10% of the surface area of the arms contacting a contaminated surface ( $0.00028\text{m}^2$ )

$$\frac{100 \text{ picograms}}{0.0033 \text{ m}^2 + 0.00028 \text{ m}^2} = 28 \text{ ng/m}^2 \text{ of 2,3,7,8-TCDD equivalents}$$

b. Minimum guideline

Assumptions - ingest contamination from 25% of the hands' surface area ( $0.016\text{m}^2$ )

- absorb 10% of the contamination with 50% of the surface area of the arms contacting a contaminated surface ( $0.014\text{m}^2$ )

$$\frac{100 \text{ picograms}}{0.016 \text{ m}^2 + 0.014 \text{ m}^2} = 3.3 \text{ ng/m}^2 \text{ of 2,3,7,8-TCDD equivalents}$$



8. Using Scenario B for contamination decreasing over time, a guideline for the initial concentration can be calculated. (N. Kim, 1982)

a.  $\frac{28 \text{ ng}}{\text{m}^2} \frac{30}{5.4} = 130 \text{ ng/m}^2$  of 2,3,7,8-TCDD equivalents

b.  $\frac{3.3 \text{ ng}}{\text{m}^2} \frac{30}{5.4} = 15 \text{ ng/m}^2$  of 2,3,7,8-TCDD equivalents

References

- The first version of this risk assessment was presented to the Expert Advisory Panel on March 29, 1982. The Summary Conclusions reached by the panel were dated August 10, 1982.
- Berkow, S.G. 1924. A method of estimating the extensiveness of lesions (burns and scalds) based on surface area proportions. Archives of Surgery 8:138-148.
- Berkow, S.G. 1931. Value of surface-area proportions in the prognosis of cutaneous burns and scalds. Amer. J. Surg. 11:315-317.
- Diem, K. and Lentner, C., eds. 1970. Scientific Tables. 7th edition. Ciba-Geigy Limited, Basle, Switzerland. p. 528.
- DuBois, D. and DuBois, E.F. 1916. Clinical calorimetry. Tenth paper. A formula to estimate the approximate surface area if height and weight be known. Archives of Internal Medicine 17:853-871.
- Eadon, G., K. Aldous, D. Hilker, P. O'Keefe and R. Smith. 1983. Chemical data on air samples from the Binghamton State Office Building. New York State Department of Health, Albany, New York 12201.
- Eadon, G., K. Aldous, G. Frenkel, J. Giertych, D. Hilker, L. Kaminsky, P. O'Keefe, J. Silkworth and R. Smith. March 1982. Comparisons of Chemical and Biological Data on Soot Samples from the Binghamton State Office Building. New York State Department of Health, Albany, New York 12202.
- Ganong, W.F. 1975. Review of Medical Physiology. 7th edition. Los Altos, CA: Lange Medical Publications.
- Guyton, A.C. 1976. Textbook of Medical Physiology. 5th edition. Philadelphia, PA: W.B. Saunders Company.
- Kim, N. and J. Hawley. 1982. Revised risk assessment: Binghamton State Office Building. New York State Department of Health, Albany, New York 12237.
- Kociba, R.J., D.G. Keyes, J.E. Beyer, R.M. Carreon, C.E. Wade, D.A. Dittenber, R.P. Kalnins, L.E. Trauson, C.N. Parks, S.D. Bainard, R.A. Hummel and C.G. Humiston. 1978. Results of two-year chronic toxicity and oncogenicity study of 2,3,7,8-tetrachlorodibenzo-p-dioxin in rats. Toxicology and Applied Pharmacology, 46: 279-303.
- Mantel, N. and W.R. Bryan. 1951. Safety testing of carcinogenic agents. Journal of the National Cancer Institute, 27(2): 455-470.

Murray, F.J., et al. 1979. Three-generation reproduction study of rats given 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD) in the diet. Toxicology and Applied Pharmacology 50: 241-252.

Poiger, H. and C. Schlatter. 1980. Influence of solvents and adsorbents on dermal and intestinal absorption of TCDD. Food and Cosmetics Toxicology. 18:477-481.

Silkworth, J., McMartin, D., DeCaprio, A., Rej, R., O'Keefe, P., and Kaminsky, L. 1982. Acute toxicity in guinea pigs and rabbits of soot from a polychlorinated biphenyl-containing transformer fire. Toxicol. Appl. Pharmacol. 55: 425-439.

United States Environmental Protection Agency. Carcinogen Assessment Group's Risk Assessment on 2,4,5-T, Silvex and TCDD. September 12, 1980a.

United States Environmental Protection Agency. Interim Evaluation of Health Risks Associated with Emissions of Tetrachlorinated Dioxins From Municipal Waste Resource Recovery Facilities. November 1981.

United States Environmental Protection Agency. November 28, 1980b. Water quality criteria documents; availability. Federal Register, 45 (231):79318.

United States Food and Drug Administration. May 30, 1980. Chemical compounds used in food-producing animals; criteria and procedures for evaluating assays for carcinogenic residues. Federal Register, 45(106): 36942-36943.

#### Health Reviews of Polychlorinated Dibenzodioxins

1. Dioxins, USEPA 600/2-80-197, Office of Research and Development, Cincinnati, Ohio, Nov. 1980.
2. The Health Effects of Agent Orange and Polychlorinated Dioxin Contaminants, American Medical Association, Chicago, Ill., October 1981.
3. Ambient Water Quality Criteria Document for 2,3,7,8-tetrachlorodibenzo-p-dioxin, USEPA, Criteria and Standards Division, 1980.
4. Huff, J. et al., Long term hazards of polychlorinated dibenzodioxins and Polychlorinated dibenzofurans, Environmental Health Perspectives, 36, 21-240, 1980.
5. Quantitative Assessment of Exposure to 2,4,5-T, Silvex and TCDD, US EPA, Sept. 1980.
6. Polychlorinated dibenzo-p-dioxins, National Research Council Canada, Publication number 18576, 1981.
7. Reggiani, G., Toxicology of 2,3,7,8-tetrachlorodibenzo-p-dioxin, Regulatory Toxicology and Pharmacology, 1, 211-43, 1981.

8. Dioxins, US EPA, 600/2-80-156, Office of Research and Development, Cincinnati, Ohio, June 1980.
9. Phenoxy Herbicides - Their Effects on Environmental Quality, National Research Council Canada, Publication number 16075, 1978.
10. Exposure Assessments for 2,4,5-T, Silvex and TCDD, US EPA, Environmental Fate Branch, Sept. 12, 1980.

QUESTIONS

1. For the surface guideline, is the 50 kilogram female the appropriate person to use for the risk assessment?
2. For the surface guideline, is the assumption reasonable that the quantity of contaminants adhering to the skin equals that found on building surfaces?
3. For the surface guideline, what percentage of the surface area of the hands should be used to estimate how much contamination is ingested?
4. For the surface guideline, what is a reasonable estimate for the body surface area exposed for dermal contact with contaminated surface?
5. For the surface guideline, what is a reasonable estimate for the absorption of contamination through the skin?