

and expected numbers of lung cancers were derived from Ohio reference rates. Environ applied the relative and additive risk models, E1 and E2, to the data in Table VI-4.

Linear relative and additive risk models fit the Luippold cohort data adequately ($p \geq 0.25$). The final models did not include the quadratic exposure coefficient, C_2 , or the background rate parameter, C_0 , as they did not significantly improve the fit of the models. The maximum likelihood estimates for the Cr(VI) exposure-related parameter, C_1 , of the linear relative and additive risk models were 0.88 per mg/m³-yr and 0.0014 per mg/m³-person-yr,

respectively. The C_1 estimates based on the Luippold cohort data were about 2.5-fold lower than the parameter estimates based on the Gibb cohort data. The excess lifetime risk estimate calculated by Environ for a 45-year working-lifetime exposure to 1 µg Cr(VI)/m³ (e.g., the unit risk) for both models was 2.2 per 1000 workers (95% confidence intervals from 1.3 to 3.5 per 1000 for the relative risk model and 1.2 to 3.4 per 1000 for the additive risk model) using a lifetable analysis with 1998 U.S. mortality reference rates. These risks were 2.5 to 3-fold lower than the projected unit risks based on

the Gibb data set for equivalent cumulative Cr(VI) exposures.

Crump *et al.* (Exs. 33-15; 35-58; 31-18) also performed an exposure-response analysis from the Painesville data. In a Poisson regression analysis, cumulative exposures were grouped into ten exposure categories with approximately two expected lung cancer deaths in each group. The observed and expected lung cancer deaths by Cr(VI) exposure category are shown in Table VI-5. Ohio reference rates were used in calculating the expected lung cancer deaths and cumulative exposures were lagged five years.

Table VI-5

Dose-Response Data From Crump *et al.* (Ex. 35-58): Observed and Expected Numbers of Lung Cancer Deaths for Luippold Cohort Grouped by Ten Cumulative Cr(VI) Exposure Categories

Cumulative Cr(VI) Exposure (µg/m ³ -yrs)	Mean Cr(VI) Exposure (µg/m ³ -yrs)	Observed Lung Cancers	Expected Lung Cancer ^b	Person-Years
0-0.00006	0.0000098	0	2.09	3112
0.00006-0.00018	0.00011	3	2.19	1546
0.00018-0.0003	0.00023	3	2.21	1031
0.0003-0.00046	0.00038	5	2.13	1130
0.00046-0.00067	0.00056	0	2.22	1257
0.00067-0.001	0.00080	4	2.23	1431
0.001-0.00163	0.00125	12	2.23	1493
0.00163-0.0026	0.0021	3	2.18	1291
0.0026-0.00445	0.00327	10	2.18	1248
0.00445-0.029	0.00755	11	2.12	904

The lower bounds of the ranges are inclusive; the upper bounds are exclusive.

^b Expected lung cancer deaths derived using Ohio state mortality rates

The Crump *et al.* analysis used the same linear relative risk and additive

risk models as Environ on the individual data categorized into the ten

cumulative exposure groups (Ex. 35-58). Tests for systematic departure from