

healthy worker effect due to the association between high cumulative exposure and long employment history; and is the least comparable to either workers exposed for a working lifetime at the proposed PEL ($1 \mu\text{g}/\text{m}^3 \times 45 \text{ years} = 0.045 \text{ mg}/\text{m}^3\text{-years}$ cumulative exposure) or welders in modern-day working conditions, who according to an IARC review cited in EPRI's comments typically have exposure levels less than $10 \mu\text{g}/\text{m}^3$ ($< 0.45 \text{ mg}/\text{m}^3\text{-years}$ cumulative exposure over 45 years) (Ex. 38-8, p. 4). In addition, the majority of the observation time in the

Luippold *et al.* cohort and the vast majority in the Gibb *et al.* cohort is associated with exposure estimates lower than $1.5 \text{ mg}/\text{m}^3\text{-years}$ Cr(VI) (Ex. 33-10, p. 455, Table 3; 25, p. 122, Table VI).

It should be noted that the levels of excess lung cancer risk observed among welders in the Gerin *et al.* cohort and chromate production workers in the Gibb and Luippold cohorts are quite similar at lower cumulative exposure ranges that are more typical of Cr(VI) exposures experienced in the cohorts. For example, the group of welders with

estimated cumulative exposures ranging from 50 to $500 \mu\text{g-yr}/\text{m}^3$ has an SMR of 230. Chromate production workers from the Gibb and Luippold cohorts with cumulative exposures within this range have comparable SMRs, ranging from 184 to 234, as shown in Table VI-11 below. For reference, 45 years of occupational exposure at approximately $1.1 \mu\text{g}/\text{m}^3$ Cr(VI) would result in a cumulative exposure of $50 \mu\text{g-yr}/\text{m}^3$; 45 years of occupational exposure at approximately $11.1 \mu\text{g}/\text{m}^3$ Cr(VI) would result in a cumulative exposure of $500 \mu\text{g-yr}/\text{m}^3$.

Table VI-11

Comparison of Gerin *et al.* exposure group and featured cohorts in cumulative exposure range of 50 - $500 \mu\text{g-yr}/\text{m}^3$

Exposure Group	SMR
Gerin <i>et al.</i> cohort (Ex. 35-220, Table 3)*	
Ever stainless steel welders, 50 - $500 \mu\text{g-yr}/\text{m}^3$	230
Predominantly stainless steel welders, 50 - $500 \mu\text{g-yr}/\text{m}^3$	214
Luippold <i>et al.</i> cohort (Ex. , Table 3)	
200 - $480 \mu\text{g-yr}/\text{m}^3$	184
Gibb <i>et al.</i> cohort (Ex. 35-435, Table 1)	
49 - $190 \mu\text{g-yr}/\text{m}^3$	197
190 - $570 \mu\text{g-yr}/\text{m}^3$	234

* restricted to workers with individual work histories, to minimize exposure misclassification

OSHA performed an analysis comparing the risks predicted by OSHA's models, based on the Gibb and Luippold data collected on chromate production workers, with the lung cancer deaths reported for the welders in the Gerin *et al.* study. Gerin *et al.* presented observed and expected lung cancer deaths for four categories of cumulative exposure: $<50 \mu\text{g-yr}/\text{m}^3$, $50-500 \mu\text{g-yr}/\text{m}^3$, $500-1500 \mu\text{g-yr}/\text{m}^3$, and $1500+ \mu\text{g-yr}/\text{m}^3$. The great majority of the Gerin *et al.* data on stainless steel welders (98% of person-years) are in the highest three categories, while the lowest category is extremely small (<300 person-years of observation). OSHA's preferred risk models (based on the Gibb and Luippold cohorts) were used to predict lung cancer risk for each of the three larger exposure categories. The

OSHA predictions were derived using the mean values from each exposure range, except for the open-ended highest category, for which Gerin *et al.* reported a mean exposure level of $2500 \mu\text{g-yr}/\text{m}^3$ (Ex. 7-120, p. S26). The ratio of predicted to background lung cancer deaths, which approximately characterizes the expected SMRs for these exposure groups, was calculated for each group.

The OSHA model predictions were calculated assuming that workers were first exposed to Cr(VI) at age 29, the average age at the start of employment reported by Gerin *et al.* (Ex. 7-120, p. S26). The SMRs reported by Gerin *et al.* were calculated for welders with at least five years of employment and at least 20 years of follow-up. However, the average duration of employment and

follow-up was not evident from the publication. The OSHA model predictions were therefore calculated using a range of reasonable assumptions about the duration of employment over which workers were exposed (5, 10, 15, and 20 years) and the length of follow-up (30, 40, and 50 years).

Table VI-12 below presents the SMRs reported by Gerin *et al.* for stainless steel welders in the three highest exposure categories, together with the ratio of predicted to background lung cancer deaths from OSHA's risk models. It should be noted that the ratio was calculated using year 2000 U.S. lung cancer mortality rates, while the SMRs reported by Gerin *et al.* were calculated using national lung cancer mortality rates for the nine European countries represented in the study (Ex. 7-114).