April 20, 2005

Docket Office
Docket H054A
Room N-2625
Occupational Safety and Health Administration
U.S. Department of Labor
200 Constitution Ave, NW
Washington, DC 20210

To whom it may concern:

Public Citizen is pleased to submit these comments in response to the Occupational Safety and Health Administration's (OSHA's) hearing on its Proposed Rule for hexavalent chromium. We believe the hearing and subsequent comment period have provided more than enough opportunity for affected industries to present evidence and raise all possible issues.

In general, the hearing provided ample justification for OSHA to lower the Permissible Exposure Limit (PEL) to at least the 1 ug/m^3 proposed. As detailed below, the record actually provides sufficient basis for a still lower PEL, the 0.25 ug/m^3 that we proposed in 1993.

Proposed PEL

The hearing left little question that hexavalent chromium is a potent carcinogen and that even OSHA's proposed PEL leaves workers at significant risk of lung cancer. Based on the Gibb study,[1] exposure to hexavalent chromium at the current PEL of 52 ug/m^3 (measured as Cr) for a working lifetime (the required assessment under the Occupational Safety and Health Act) would result in 351 excess lung cancer deaths per 1,000 workers (95% confidence interval [CI]: 181-493).[2] Even under OSHA's proposed PEL of 1 ug/m^3, the Gibb study yields an estimate of 9.1 excess lung cancer deaths per 1,000 workers exposed for a working lifetime (95% CI: 4.0-16.0).[3] At the recent hearing, this level of risk was deemed by Dr. Gibb to be "a statistically significant risk"[4] and was considered "too high"[5] by Mr. Kojola, the AFL-CIO representative. OSHA itself acknowledges that "even at the proposed PEL, the risk posed to workers with a lifetime of regular exposure is still clearly significant."[6]

The estimate only dips below the 1/1,000 excess lifetime risk used as a yardstick in the 1980 Supreme Court decision in the *Benzene* case[7] when the PEL is lowered to 0.25 ug/m^3, the PEL for which Public Citizen and the Oil, Chemical, & Atomic Workers Union (OCAW, now the Paper, Allied-Industrial, Chemical and Energy Workers

International Union, PACE) petitioned in 1993.[8] OSHA explicitly states in the Notice of Proposed Rulemaking (NPRM) that 1/1,000 is the minimum protection that must be afforded workers: "OSHA has generally considered, at [a] minimum, [a] fatality risk of 1/1,000 over a 45-year working lifetime to be a significant health risk."[9, 10] Dr. Schulte of the National Institute for Occupational Safety and Health (NIOSH) pointed out the limitations of OSHA's proposed PEL when he testified, "we've identified that there are significant risks [at the proposed PEL], and a lower PEL would reduce those risks to that area [a risk of 1/1000]."[11] Indeed, NIOSH actually recommends a PEL of 0.2 ug/m^3, which is even lower than what Public Citizen/PACE have proposed. This represents a major shift in NIOSH's position from its 1975 recommendation of a PEL of 1 ug/m^3. We therefore stand by our assessment that the elimination of significant risk to workers can only be assured at a PEL of 0.25 ug/m^3.

Although most industry groups have refrained from advocating a specific PEL even while objecting to OSHA's proposal, the Surface Finishing Industry Council proposes a new PEL of 23 ug/m^3 on the theory that the Luippold study[12] showed no excess lung cancers below that level.[13] (Note that this conveniently ignores the vastly superior Gibb study, which did show elevated lung cancer risks at 23 ug/m^3.) The authors of the Luippold study, however, made no claim that their data demonstrated an absence of risk below that level (or any other). Rather, they acknowledged that because of the small amount of data, their estimates for lower exposure categories had "wide confidence intervals," and they warned that any conclusion as to risk at lower exposures "should be considered cautiously given the small number of lung cancer deaths observed, especially in the lower exposure categories."[14]

Moreover, the Surface Finishing Industry Council's principal witness (who co-authored and signed the Council's comments) conceded that he did not know whether the Luippold study's authors agreed that there was no significant risk below 23 ug/m^3, that he did not know whether any scientific evidence had been submitted in support of that interpretation of the study, and that he did not know what "credible health experts" or "independent evaluations" of the data supported the Council's position.[15] The one co-author of the Luippold study who did testify, Deborah Proctor, nowhere claimed that there was no significant risk below 23 ug/m^3. Moreover, she acknowledged that the Luippold study's findings were consistent with a linear relationship between exposure and risk, and she did not even argue that a "threshold" was possible, but only that there might be some "sub-linearities" at exposure levels she could not quantify.[16]

Notably, if the Surface Finishing Industry Council's unsupported claim that there is no significant risk below 23 ug/m^3 is set aside, no basis remains for its suggestion that the PEL be set at that level. The Council's witnesses all acknowledged that a significantly lower PEL would be both technologically and economically feasible, although they generally declined to set a lower bound to what they admitted was feasible.[17]

Risk Assessment

In its risk assessment, OSHA has relied primarily on two epidemiologic cohort studies, the Gibb[18] and Luippold[19] studies, to estimate the lung cancer risk for workers exposed to hexavalent chromium. In our previous comments to OSHA,[20] we disagreed with the agency's decision to give equal weighting to the two studies, because the Gibb study is superior in many respects: the number of workers, person-years of follow-up, number of lung cancer deaths, exposure assessments and smoking assessments. The testimony at the hearing provided ample substantiation for this position. Dr. Gibb himself explained during cross-examination how his study is superior and said very plainly, "I think it is the best study."[21] He attributed his study's superiority to an "information advantage." He noted that his study used hexavalent chromium exposures taken randomly (not for cause) that are in the range of the proposed PEL when measured cumulatively, allowing one to interpret the data directly without extrapolation.[22] This point was supported by Drs. Park and Schulte, representatives from NIOSH, who testified that the Gibb data are "the preferred data set [due to] a large number of lung cancer cases, relatively very good smoking information, and relatively exquisite exposure history information."[23]

However, by weighing the Gibb study and the Luippold study equally and using the maximum likelihood estimate from the Luippold study as the lower bound for the risk assessment, OSHA has reduced the apparent risks of hexavalent chromium and opened the door to a higher PEL than is necessary to protect worker health. Our preference would be to rely upon the Gibb data alone, as they are much superior to Luippold. In the alternative, in our testimony we offered a series of methods for weighing the two studies, including weighing the Gibb and Luippold studies in proportion to the variability in the studies, the number of workers, the expected number of deaths, or the number of person-years of follow up.[24]

A common theme in industry criticisms of the Gibb study is that it involved chromate production workers who were exposed to levels of hexavalent chromium significantly higher than those prevalent in industry today.[25] According to this criticism, although the Gibb study included workers with very low cumulative lifetime exposures to hexavalent chromium, those cumulative exposures were the result of very short-term exposures to very high airborne concentrations of hexavalent chromium; thus, the argument goes, the study is not a reliable basis for risk estimates applicable to longer-term exposures to much lower concentrations.

This criticism is unwarranted. The evidence in the record about the Gibb study demonstrates that it involved workers exposed to a range of airborne concentrations, including concentrations that are well below the current PEL, and that compare favorably not only to those prevalent in industry today, but also to OSHA's proposed PEL.

Far from involving an antiquated plant with extremely high exposure levels, the Gibb study involved workers at a chromate facility that was newly constructed in 1950 and employed advanced measures to reduce exposures.[26] Thus, even in the 1950s, "usual" exposures in the plant were only about 31 ug/m^3, well below the current PEL.[27] Moreover, the plant remained in operation until relatively recently — 1985 — and the

study included workers exposed up to the most recent periods of the plant's operation, when exposures were likely even lower.[28]

Moreover, although Dr. Gibb's principal publication on the study provides only cumulative airborne concentrations, data included in his companion publication on dermatological toxicity show that the *median* exposure of workers who reported acute symptoms associated with hexavalent chromium exposure (such as irritated nasal septum) was 20-28 ug/m^3 as chromic acid, or 10-14 ug/m^3 as chromium.[29] Given that these were median exposures, it follows that half of the workers who reported such symptoms must have been exposed to even lower levels.

In addition, the extremely low cumulative exposures reported by Dr. Gibb for much of his cohort, when divided by the average number of years workers in the study were employed, yield results indicating that many of the workers studied must have been exposed to airborne concentrations well below the current PEL.[30] Dr. Gibb's raw data, which have been supplied to OSHA, fully bear out this conclusion.[31] Indeed, the data show that the exposure of many of the study's subjects during the study period was near or even below the proposed PEL of 1 ug/m^3. Dr. Gibb's post-hearing comments further demonstrate that the study's subjects included many workers whose average annual exposures were quite low relative to the current PEL.[32]

The present state of the science of hexavalent chromium toxicity does not permit differentiation between high levels of hexavalent chromium exposure for a short period of time and low exposures for longer periods of time. The cumulative exposure metric is thus the only available alternative and the metric consistent with the requirements of the Occupational Safety and Health Act.

Finally, even if there were some merit to the notion that the airborne concentrations to which the subjects of the Gibb study were exposed were high relative to exposures prevalent today, the study would remain the best source of data for risk estimates because there is no other study that analyzes comparable amounts of data for workers with low cumulative exposures to hexavalent chromium. Indeed, most of the studies referenced by various industry witnesses lack individual hexavalent chromium exposure data altogether and cannot be used for risk estimates. And the Luippold study, whose results some industry witnesses claim to prefer to those of Gibb, actually involves workers exposed to much higher concentrations of hexavalent chromium.

Threshold Effect

Typically, when OSHA attempts to regulate any occupational carcinogen, industry will claim that there is a threshold effect (i.e., that chemicals lose their ability to cause cancer below some exposure level). A related concept is that the dose-response data are non-linear — that the rate of disease does not increase with exposure in a straight line. The hexavalent chromium proceeding has been no exception. Wherever the industry looks for a threshold effect, they claim to find one, be it with respect to dermal effects, animal studies, mechanism of action, or epidemiological studies. However, as we indicated in our previous

comments, OSHA correctly found problems with the threshold argument in each of those areas. Furthermore, both the risk assessment conducted on contract for OSHA by Environ and another by NIOSH found that non-linear models fail to characterize the data in the Gibb study more accurately than simpler linear models.

Testimony provided in the course of the hearing fortified our position that there is no evidence of a threshold effect. Dr. Schaeffer, OSHA's toxicologist, stated that "[there is] no convincing evidence of a threshold"[33] with respect to animal studies. He went on to say that "the mode of action study suggested that hexavalent chromium was a genotoxic agent, and that would lead us to believe it would not have a threshold."[34] Consistent with Dr. Schaeffer's views, OSHA stated in its NPRM that it "does not believe that there is sufficient scientific evidence"[35] to support assertions of non-linearity based on these mechanistic data. In addition, Dr. Clewell, a toxicologist at Environ Health Sciences, testified "I really don't have a method of providing some reliable basis for doing a dose response apart from the linear on the basis of the level of information that's available."[36] Dr. Clewell concurred that even if the data from a mechanistic study show non-linearity there is no way to "convert those [results] in any reliable, quantitative fashion" to a putative threshold in an epidemiological study.[37]

Regarding epidemiological studies such as Luippold's, industry claims again that the dose-response data are nonlinear. Here, too, Dr. Schaeffer clearly disputed this when he stated that "epidemiological evidence is generally not sufficient to establish whether there is a threshold."[38] Other scientific experts concurred. Dr. Gibb stated in his testimony, "I haven't seen an argument advanced for why there was a threshold that I would consider credible."[39] This opinion was also supported by Dr. Petsonk, a representative of NIOSH.[40] Even an industry representative (Ms. Fessler from the steel industry) admitted that her statement that there might be a threshold "is simply because its possible in the world, not because of anything [she's] particularly seen, calculated, determined, or read."[41] Ms. Proctor of the Aerospace Industry Association of America agreed that in the Luippold study, of which she was a coauthor, the data "fit a linear model"[42] and concurred that "no monotone dose response would fit these data any better than the linear model."[43] This is consistent with the Luippold paper itself, which acknowledged that when the data were tested for linearity, "this test showed no departure from linearity, indicating that a linear model may be compatible with the data."[44] Similarly, NIOSH's post-hearing comments again concluded (based on analysis of the Gibb cohort) that "examination of non-linear features of the hexavalent chromium-lung cancer response supports the use of the traditional (lagged) cumulative exposure paradigm: no threshold, linearity in intensity, and constant increment in risk following an exposure."[45]

We are encouraged that, even in the face of a barrage of misleading information from industry, OSHA has stuck to its principles in the NPRM and declared that "[I]n accordance with the Agency's long standing cancer policy, OSHA believes it is inappropriate to establish a threshold or 'no effect' level of exposure to a carcinogen."[46] We urge the agency to stand by that view.

Pigments

Scientific experts agree that the most reasonable approach to the regulation of the various hexavalent chromium compounds is to consider them all to be carcinogens. As we described in detail in our previous comments, as early as 1984 many agencies, such as the Environmental Protection Agency (EPA), NIOSH and the International Agency for Research on Cancer (IARC) concluded that all hexavalent chromium compounds, including chromium pigments, are carcinogenic to humans.[47,48,49] Testimony at the recent hearing confirmed this approach.

The Color Pigment Manufacturers Association (CPMA) has consistently claimed that its products are somehow exempt from the cancer-causing propensities of other hexavalent chromium chemicals. The industry even went so far as to petition OSHA for a higher PEL for hexavalent chromium-containing pigments. However, the record compiled by OSHA makes a convincing case that hexavalent chromium-containing pigments are indeed carcinogens. At the recent hearing, even Dr. Marr, representing Dominion Colour Corporation, agreed that a recent study from 2004, omitted from the CPMA testimony, shows that lead chromate is both cytotoxic and genotoxic.[50] (Incidentally, CPMA claims that an analysis of the 2004 study by a Dr. Nestmann concludes that the study "should not even have been accepted for publication."[51] As CPMA acknowledged during cross-examination, Dr. Nestmann was paid for this review, although CPMA refused to divulge how much. Astonishingly, Dr. Nestmann's comments, attached as Appendix D to the CPMA comments, do not even remotely refer to whether the study should have been published, despite the CPMA claims.) Mr. Cox, of Dominion Colour Corporation testified that his company stopped producing zinc chromate after the Davies study showed that it causes cancer.[52]

If anything, some of the chemicals involved in pigment production might be considered more carcinogenic than some of the other hexavalent chromium compounds, such as chromic acid and the sodium chromates that workers were exposed to in the Gibb and Luippold studies. At the hearing, a number of scientific experts testified on this very point. Dr. Clewell, a toxicologist at Environ Health Sciences, stated that "the solubility of hexavalent chromium compounds influences their carcinogenic potency with the slightly soluble compounds [a category including many pigments] having the higher potencies."[53] Ms. Proctor from the Aerospace Industry Association of America agreed that strontium and zinc chromates, the two forms of chromate primarily used in the aerospace industry, "are typically quantified -- described as sparingly soluble."[54] Dr. Schaeffer, a toxicologist from OSHA, also addressed this point: "There is data to suggest that there is a difference in carcinogenic potency among different chromates. But our risk assessments relied on workers exposed to highly soluble chromates that appear to be less potent than some chromates, and at least not more potent than others."[55] Ms. Woodhull, a consultant from ORC World Wide, an international management and human resources consulting firm that specializes in occupational safety and health consulting services for industry, agreed that "it appears that all hexavalent chromium compounds should be regulated in this proceeding."[56] Dr. Schulte of NIOSH agreed that some hexavalent chromium compounds may be more carcinogenic than others and that the sodium chromates to which the subjects of the Gibb study were exposed are among the less carcinogenic compounds. He concluded that

OSHA's risk assessment may in fact be a conservative estimate of the true risk for more potent types of chromium.[57] In post-hearing comments submitted by NIOSH the agency calculated a relative risk of 1.56 associated with exposure to pigments and estimated that this corresponded to a lifetime excess risk for working with pigments of approximately 110 to 200 lung cancer cases per 1,000 workers.[58]

Incidentally, much of the discussion regarding the carcinogenicity of pigments, especially lead chromate, seems to be irrelevant given that the CPMA testified in the hearing that "there are no major manufacturers of lead chromate pigments in the US,"[59] an astonishing admission given the CPMA's longstanding involvement in this issue. All lead chromate is obtained from foreign sources. Moreover, the domestic users of lead chromate pigments have little need for a less-protective standard, both because exposures in their industry are already well controlled (in part as a result of the lead standard) and because substitutes for lead chromate pigments are readily available and have already nearly driven lead chromate pigments from the market.[60] In addition, as the painting industry witnesses conceded, there is no arguable basis for a less-protective PEL for the other hexavalent chromium compounds used in pigments and paints: zinc chromate, strontium chromate, and sodium dichromate.[61]

Hierarchy of Controls

In the NPRM, OSHA outlined the hierarchy of controls expected to be utilized to achieve the desired PEL: "Primary reliance on engineering controls and work practices is consistent with good industrial hygiene practice and with OSHA's traditional adherence to a hierarchy of preferred controls."[62] After listing all the various engineering controls and work practices, it states that "the supplemental use of respiratory protection if engineering controls are not sufficient to meet the proposed PEL"[63] is permitted by the proposed rule. The concept of utilizing a hierarchy of controls to reach a PEL is sometimes contested by industry. However, even Mr. Colton, representing 3M, a company that manufactures personal protective equipment (PPE), when asked directly if he agreed with OSHA's general principle that one should exhaust the engineering control options before initiating respiratory protection through PPE, clearly stated, "We support OSHA's hierarchy of controls."[64] Mr. White of ORC, an industry consulting group, testified that "ORC over the years has unfailingly supported OSHA's application [of] the hierarchy of controls in its health standards, and the general requirement that personal protective equipment may be used to reach the PEL only if the employer can demonstrate that the additional controls are not feasible."[65] Mr. White, however, advocated an exception to this longstanding principle in this case, based on what he called "special circumstances." These circumstances turned out to be the same ones present in nearly every OSHA rulemaking — that is, "uncertainty" about the efficacy of engineering controls in a limited number of applications. Such circumstances, which are virtually ubiquitous in the regulation of workplace substances, fail to justify a departure from OSHA's long-established hierarchy of controls.

Economic feasibility

Because we have established and OSHA has acknowledged that there is still significant risk at the proposed PEL of 1 ug/m^3, we are advocating lowering the PEL to a more worker-protective level of 0.25 ug/m^3. We believe that this level is economically feasible. The economic assessment prepared by OSHA indicates that, in general, reaching the proposed PEL of 1 ug/m^3 is well within the reach of the affected industries. The annualized incremental cost to comply with the new PEL is $223 million for industries with annual revenues of $721 billion (0.03%). Although the costs can fall disproportionately on particular industries and smaller business entities, in only one industry (chromium catalyst production with three business entities employing 313 people, or 0.08% of the 381,000 workers affected by the standard) did the incremental costs exceed one percent of revenues (1.07%). In only four industries representing no more than 19% of workers affected by the standard do these costs exceed 10% of profits. We therefore agree with OSHA that "the proposed standard is economically feasible."[66]

In fact, OSHA's data indicate that it would be economically feasible to set the PEL at a still lower level. At our proposed PEL of 0.25 ug/m^3, the annualized incremental costs increase to $544 million. Even this represents only .08% of the revenues of all the industries affected by this rulemaking. There appear to be six industries with incremental costs that would be greater than 1% of revenues, and they represent 80,121 workers, 21% of those affected by this rulemaking.

Drawing from OSHA's economic analysis,[67] we compiled Appendix 1, which summarizes exposure profiles for the six industries for which a PEL of 0.25 ug/m^3 would create costs greater than 1% of revenues. As Appendix 1 demonstrates, 75% of the 80,121 workers in those industries are in construction welding. Even among these six industries, a significant fraction of workers are in work places that are already compliant with the PEL. Forty-one percent (33,097) are already below the 0.25 ug/m^3 PEL that we suggest, and a further 19% (15,032) are in the window between the 0.25 ug/m^3 that we recommend and the PEL of 1 ug/m^3 that OSHA is proposing. Forty percent (31,992) are above 1 ug/m^3.

Thus, issues of economic feasibility involve only a limited number of workers heavily concentrated in welding in the construction industry, a large fraction of whom are already compliant with a PEL of 1 ug/m^3 and almost half of whom are compliant with 0.25 ug/m^3. These data provide no basis for concluding that it is economically impossible for all hexavalent chromium industries to comply with a PEL of 0.25 ug/m^3, especially given the significant health risks that exist at OSHA's proposed PEL of 1 ug/m^3.

A frequent objection raised by industry with regard to economic feasibility is that the OSHA standard would create a risk to the economic viability of the industry as a whole, especially small businesses. This claim is often made but rarely substantiated, as seen when reviewing the experience with prior standards. For example, at the recent hearing, the EPA representative discussed establishing the maximum achievable control technology (MACT) for air emissions of chromium under Section 112 of the Clean Air Act. He confirmed that, despite industry claims that the chromium MACT would impose unreasonable costs on small businesses in the chrome plating industry, eight years later the plating industry is still characterized by a large number of small business entities.[68]

In addition, in proceedings to establish prior standards, industry has often presented cost estimates to implement a new standard that are considerably higher than OSHA's. However, frequently OSHA's estimates are themselves overestimates of actual costs when the standard is implemented. At the hearing, a representative of United Steelworkers of America cited a report done by the Office of Technology Assessment that examined cost estimates for prior standards. He mentioned two in particular, the benzene and vinyl chloride standards. In his testimony, he described in detail what happened with vinyl chloride: "The report [by a contractor for the plastics industry on economic feasibility], as I remember, said basically that the cost of compliance with the OSHA vinyl chloride standard would be so great that the price of the plastic would dramatically jump and every vinyl chloride plant, every plant that makes vinyl plastic in the U.S. would close down several years after the standard went into effect. I don't know the exact numbers but one or two had closed down but additional ones had opened up. The price of the plastic had actually dropped due to economic circumstances. People were still making money making it. We still make it in this country and those costs that had been estimated by the industry were overblown by several orders of magnitude. That may be an extreme case but industry estimates are usually pretty high."[69]

Despite the extensive and comprehensive analysis of affected industries that OSHA has done to demonstrate the economic feasibility of its proposed standard, many of those industries have submitted comments and testimony in these proceedings contending that compliance would be economically infeasible. At the hearing, however, industry witnesses repeatedly conceded on cross-examination that exposures were currently at or below the proposed PEL in all, many or most of their operations (thus demonstrating the feasibility of compliance);[70] or that they did not know whether their operations exposed workers above the proposed PEL (rendering their assertions of infeasibility speculative or unpersuasive);[71] or, in those instances where engineering controls have purportedly failed to reduce exposures to the PEL, that workers currently use respiratory protection that reduces their exposure to levels below the PEL (demonstrating the feasibility of compliance through PPE)[72]; or that the costs of compliance are not so great as to threaten the economic viability of the entire industry (showing that the standard, even if costly, is not economically infeasible).[73] We urge OSHA to review the record closely and to be skeptical of industry claims of infeasibility that are belied by industry witnesses' own testimony that protection of workers is possible. [74]

Even with respect to plating, where industry's claims of economic infeasibility were most pronounced, industry witnesses conceded that existing facilities, using control technologies installed decades ago, are capable of at least closely approaching the proposed PEL.[75] OSHA's data also show that at least some facilities in this industry are currently capable of complying. Further, the plating industry's claims of economic infeasibility rest to a significant degree on testimony concerning unprofitable operations that may already lack economic viability for reasons unrelated to possible regulation.[76] Such evidence does not demonstrate that profitable firms will be driven to economic non-viability by increased regulation. Finally, even assuming that the plating industry's high cost estimates, which significantly exceed those of OSHA and its contractor, were

correct, industry witnesses consistently testified that PELs significantly below the existing one would be feasible, and that their own proposed PEL of 23 ug/m^3 was not the limit of economic feasibility.[77]

Technological feasibility

With the proposed PEL still leaving significant health risk, and a PEL as low as 0.25 ug/m^3 being economically feasible, the only possible rationale for not reducing the PEL to 0.25 ug/m^3 would be lack of technological feasibility. OSHA's only justification in the NPRM in claiming this lack of feasibility is literally as follows: "PELs lower than 1 ug/m^3could not be achieved by means of engineering controls and work practices alone for some types of welding (particularly [gas metal arc welding] and [shielded metal arc welding]) and in hard chromium plating."[78] At the recent hearing, a representative from Shaw, OSHA's consultant that compiled the technological feasibility assessment, testified that welding and chrome plating were "the areas that stood out as the ones that seemed most difficult to be feasible from a technological point of view."[79] When questioned about whether it is technologically feasible for most industries to get below a PEL of 1 ug/m^3, a Shaw representative stated that it was feasible "because the exposure profile shows that exposures [in a number of industries] are below the proposed PEL of one as they exist now."[80]

A closer examination of these two sub-industries — hard chrome electroplating and arc welding — shows that hard chrome involves 1,678 workers, which is 0.4% of all the workers affected by this rulemaking. Within that industry, 42% of the facilities are already compliant with our proposed 0.25 ug/m^3 PEL. Arc welding is a more complicated sub-industry, but the NPRM provides little justification for showing that a PEL of 0.25 ug/m^3 is infeasible even in welding. For shielded metal arc welding in general industry, 33% of workers are already below 0.25 ug/m^3, and 55% of gas metal arc welding workers are already below that level.[81] At most, the remaining 67% and 45% of workers would need (PPE) to come into compliance with any lower PEL.

Importantly, these levels of potential PPE use did not lead Shaw to conclude that a lower PEL is infeasible. Indeed, it seems that OSHA is making its on own judgment about technological feasibility that is not consistent with Shaw's assessment and is poorly justified. When OSHA discusses technological feasibility for the welding industry (general industry) it states: "OSHA estimates that this combination of controls, various forms of ventilation, would achieve exposures in the range of .3 to .4 micrograms per cubic meter if the system can be properly balanced. However, these high rates of general mechanical ventilation needed to reduce the welder's exposure to below .5 *may* interfere, with the performance of the LEV systems also needed. This option *may* be difficult to balance and therefore, *may* not be viable in practice" (emphasis ours).[82] OSHA concludes its discussion with the statement that "OSHA does not believe at this time it is feasible for [the] majority of the welders in general industry to obtain exposure routinely below 0.5 ug/m^3."[83]

However, nowhere in the Shaw report is there any mention of even a potential problem in balancing the ventilation. At the recent hearing, when asked specifically about this issue, a Shaw representative stated: "The controls mentioned are familiar to me, that we did describe those controls. What I'm not familiar with is summarizing the combination of all these four and how they may interfere with each other. That is not a concept that we came up with … [the conclusory comment is not] in our report."[84]

At the very least, OSHA must explain how it came to those conclusions. Absent such an explanation, OSHA's claim that it is technologically infeasible to get below the proposed PEL of 1 ug/m^3 hardly qualifies as adequate justification for denying welding workers the additional health benefits required by law, let alone for establishing 1 ug/m^3 as the PEL for workers in all other industries as well. Given that the claim of technological infeasibility for these particular applications is the only explanation OSHA has offered for concluding that a lower PEL would not be feasible across the board, it is evident that OSHA has failed to offer an adequate justification for not reducing risk further.

Appendix 2 shows each of the 32 affected industries and the PELs at which any of their workers would be required to utilize respiratory protection in order to comply with that PEL. The appendix was created by extracting from the Shaw report the controls needed to achieve each potential PEL for every worker/job category for each of the 32 industries. The table demonstrates that, even without PPE, a large number of industries could be compliant with 0.25 ug/m^3, 0.5 ug/m^3, and 1 ug/m^3. In over 50% of industries (18/32), no PPE would be required to reach a PEL of 0.25 ug/m^3. These industries employ 143,272 affected workers, or 38% of the total workers exposed to hexavalent chromium (143,272/380,599). In contrast, in seven industries some workers would require PPE even at a PEL of 1 ug/m^3. Electroplating and welding are two of these industries and were the only two cited by OSHA as precluding a PEL lower than 1 ug/m^3. Four of the five remaining industries are small industries, affecting less than 350 workers in each.

A closer examination of the electroplating and welding industries reveals that the majority of workers in even these industries are already below 0.25 ug/m^3. According to the exposure monitoring data presented in the NPRM, currently 64% of workers in electroplating are already below 0.25 ug/m^3, 6% are between 0.25 ug/m^3 and 1 ug/m^3 and 31% are above 1 ug/m^3. In welding, 46% of workers are below 0.25 ug/m^3, 10% are between 0.25 ug/m^3 and 1 ug/m^3 and 44% are above 1 ug/m^3.[85] Based on the data from the NPRM, at our proposed PEL of 0.25 ug/m^3, 7,229 electroplating workers and 25,211 welders would need PPE.[86] This represents only 8.5% of all workers affected by the hexavalent chromium standard (32,440/380,599).

It is important to remember that even though hard chrome and welding are the areas that OSHA has identified as most difficult to bring into compliance with a lower PEL on the basis of technological feasibility, there are many other workers in other sub-industries that could achieve a PEL lower than 1 ug/m^3, and they will all be affected by OSHA's failure to compel a PEL lower than 1 ug/m^3. Thus, the agency's unwillingness to propose a lower PEL has a ripple effect that is not confined to the most difficult-to-reduce industries, but rather permeates the entire rulemaking. This will result in large numbers of additional

workers not getting the best protection that can be afforded and accomplished technically, even though a "significant risk" remains for them.

If the PEL is set at OSHA's proposed level of 1 ug/m^3, many workers whose exposure could be reduced to a level lower than 1 ug/m^3 could instead be exposed to 1 ug/m^3, which carries a significant risk of 9 excess lifetime lung cancer deaths per 1,000 workers, according to the Gibb study. Based on Table IX-3 in the NPRM, which outlines the PPE use by industry at various potential PELs after engineering and work practice controls have been applied, only 48,058 (12.7%) workers would need respiratory protection in order to achieve a PEL of 0.25 ug/m^3.[87] Of those, 68% (32,440/48,058) are in just two industries, electroplating and welding. If the PEL were established at 1 ug/m^3, instead of at 0.25 ug/m^3, 143,402 (38%)[88] would be denied better protection (without PPE) and would be unnecessarily exposed to significant risk.

Legal analysis of technological feasibility

Nothing in the Occupational Safety and Health Act suggests that a workplace exposure standard for a hazardous substance that can be fully met only through the use of respirators is, necessarily, technologically infeasible. The Act itself says only that "[t]he Secretary, in promulgating standards dealing with toxic materials or harmful physical agents under this subsection, shall set the standard which most adequately assures, to the extent feasible, that no employee will suffer material impairment of health or functional capacity even if such employee has regular exposure to the hazard dealt with by such standard for the period of his working life."[89]

The Supreme Court has held in the *Cotton* Dust case that the meaning of "feasible" is "capable of being done," or *possible*.[90] The *Cotton Dust* decision also confirmed that feasibility includes both a technological and an economic component: technological feasibility means that it is physically possible to meet the standard, and economic feasibility means that implementing the necessary technological improvements will not drive the industry out of business.

In requiring that significant health risks be eliminated to the extent possible, the statute does not say "unless it is possible only through the use of respirators." Indeed, the statute itself does not rule out any means of achieving protection of workers, as long as it is feasible. Thus, logically, if exposure to a substance above a particular concentration subjects workers to a significant risk of illness, and their exposure could be reduced to that level through the use of respirators without threatening the economic viability of the affected industry, it would be both technologically and economically feasible to limit exposure to that level. Moreover, if respirators were the *only* way to achieve that level of protection, the statute would *compel* OSHA to require their use. Indeed, in the *Cotton Dust* case itself, the Supreme Court upheld OSHA's determination that its cotton dust standard was feasible even though the standard placed "heavy reliance on the use of respirators to protect employees from exposure to cotton dust."[91, 92]

In short, there is no basis at all in the statute for the notion that a standard is necessarily infeasible if it can be met through the use of respirators (either on their own or in combination with engineering controls). If respirators that permit the standard to be met are available and adaptable to use in the affected industry, their use is technologically feasible, and if using them would not drive the industry out of business, their use is economically feasible.

Of course, OSHA, for very sound policy reasons (among them the difficulties, dangers, and disadvantages of using respirators), has a longstanding policy preference for achieving PELs for hazardous substances in the workplace through engineering controls and workplace practices rather than through respirators and other PPE. Thus, OSHA standards typically require employers to meet PELs through engineering controls and workplace practices if and to the extent feasible. Only if those measures cannot feasibly meet the PEL may the employer rely on respirators to go the remaining distance toward compliance (or as far as feasible toward compliance). In addition, OSHA's standards typically presume that the PEL can be met through engineering controls and workplace practices, and require employers to prove these measures could not feasibly meet the PEL before they may rely on respirators to make up the difference.

The question is whether such a standard may be considered feasible if in some cases the engineering controls and workplace practices will not suffice, and employers will be forced to rely on respirators.

One view, adopted early on by the U.S. Court of Appeals for the Second Circuit, is that as long as the respirator option is there as a fail-safe, and as long as meeting the PEL with respirators is technologically and economically feasible, such a standard meets the feasibility criterion. The Second Circuit put forth this interpretation of the statute in upholding OSHA's vinyl chloride standard, which required industry to meet a PEL of 1 ppm, substantially lower than any manufacturer in two of the most affected industries had yet attained. The industry argued that it would "never" be able to meet the standard through engineering means. OSHA responded that with anticipated improvements in technology, it expected that they could.

The court endorsed OSHA's view that industry would likely be able to meet the standard through engineering controls in the future, but also emphasized that "whether it can or not, the Secretary's compliance scheme does not rest only on engineering and work practice controls. He does mandate that the industry use such technology to the extent feasible, but, more importantly, he requires that, in addition, respiratory protection be used if engineering means cannot bring the [vinyl chloride] level down to the permissible limit."[93] The court went on to point out that respirators, whatever their drawbacks, "effectively eliminate exposure to [vinyl chloride]," are practical to use, are inexpensive, and are "reasonably available."[94] In short, the court held that the standard was feasible *because* it could be met through the use of respirators.

The U.S. Court of Appeals for the D.C. Circuit took a somewhat different tack in the *Lead* decision.[95] The court was troubled by what it called the "circularity" of the Second

Circuit's view that a standard is feasible if it requires engineering controls and workplace practices only to the extent feasible and otherwise permits reliance on respirators. Because an employer who did not meet the PEL through engineering controls and workplace practices would bear the burden of proving their infeasibility in order to avoid sanctions in an enforcement action, the court thought that the Second Circuit's view let the agency off the hook too easily, since it is the agency's burden to show that its standard is feasible in the first instance.

Thus, to support a standard that requires an employer to meet the PEL through engineering controls and workplace practices if possible and permits reliance on respirators only as a fallback, the court in the *Lead* case held that the agency must show that there is a *reasonable possibility* that a *typical* firm will be able to meet the PEL through engineering controls and work practices in *most of its operations* without respirators.[96] The agency does not have to show that technology already in widespread use (or even cutting-edge technology that has just been developed) will currently allow a typical firm to meet the standard, because the agency is supposed to adopt technology-forcing standards. But if it wants to rely on technology-forcing, it at least has to have a reasonable basis for believing that the technology will be available within the time-frame for compliance with the rule.

The court stressed that this did not mean that the need for respirators in a "few" operations in an industry would mean that the standard was not feasible.[97] For example, in the smelting industry, OSHA conceded that in the "drossing" operation and in maintenance, respirators would be required to meet the standard, but the court held that this did not mean that the standard was infeasible for the entire industry (nor that a separate standard had to be created for those operations where respirators would be needed).[98] The court held the same to be true of "scrap handling" and maintenance operations in the secondary smelter industry.[99]

Later cases following the approach of the *Lead* case illustrate that a standard that places principal reliance on engineering controls and workplace practices can be upheld as feasible even if respirator use will still be necessary to achieve compliance in significant numbers of operations within an industry. For example, in the arsenic standard,[100] the U.S. Court of Appeals for the Ninth Circuit upheld OSHA's arsenic standard even though the standard would require "limited" use of respirators in 11 of 16 affected smelters and "limited-to-moderate" use in the remaining five. The court held that the need for respirators to achieve the standard did not make it "infeasible," "unreasonable" or "inappropriate."[101]

Similarly, the D.C. Circuit held that OSHA's asbestos standard was technologically feasible even though it would require the use of respirators to achieve compliance for just below 10% of the affected workforce.[102] (OSHA had calculated that 12.7% of affected workers would require PPE in this instance.) The court approvingly noted that "[a]s to operations that cannot be brought into full compliance with the PEL through engineering and work practices, OSHA has provided that the employer must use them to attain the

lowest achievable levels and supplement them with respirator use,"[103] and it stated that this approach was fully consistent with the approach to feasibility in the *Lead* case.

Finally, the D.C. Circuit revisited the lead standard.[104] In the earlier *Lead* decision, the court had found that OSHA had not adequately supported its standard for certain industries and had remanded for the agency to try again. When OSHA again imposed the standard on those industries, they again appealed. The lead chemicals industry, in particular, argued the standard was technologically infeasible in light of OSHA's concession that certain packaging and shipping operations (involving about 15% of industry shipments) as well as maintenance operations would require use of respirators. Again, the court held that the inability to meet the standard in these operations without respirators did not invalidate the feasibility of the standard where "most of the operations in the industry can meet the standard with engineering and work practice controls."[105]

In sum, the judicial decisions, while reflecting some differences in approach, make clear that the existence of some need for respirator use to meet a PEL will not invalidate the standard on technological feasibility grounds.

The likely need for respirators in some operations in some industries to meet a hexavalent chromium PEL of 0.25 ug/m^3 thus does not mean that the standard is infeasible for those industries, let alone for others that do not require respirators to reach that level. In other words, it is not enough for OSHA to say that the PEL should be at a particular level because some industry cannot get lower than that without respirators. Moreover, if a significant risk remains at that level, and if it can feasibly be eliminated through the use of respirators, OSHA must either require them or explain why it has not done so — for example, it must provide reasons for concluding that their use would be technologically or economically infeasible.

One might consider that OSHA's whole approach to this proposed PEL as a highest common denominator approach to regulation — looking for the level that everybody can definitively comply with. This approach needlessly leaves many workers at significant risk. From a public health perspective, this does not seem to us to be the best approach to take when trying to establish a standard that will protect all workers in all affected industries, and from a legal perspective, it is not a permissible approach. Even if OSHA were correct about the lack of technological feasibility in two industrial subcategories, the standard could be tailored to take these processes into account or to allow longer phase-in for selected industries or processes. Or, if the agency can adequately justify the technological infeasibility of a lower PEL for welding and hard chromium plating, this would seem like the ideal situation for a Separate Engineering Control Air Limit (SECAL). In no event, however, may workers in all industries be denied adequate protection because of technological considerations applicable to only a few workers in a handful of subindustries.

Separate standards for general industry, construction and maritime and exposure monitoring

We continue to believe that it is exposure to hexavalent chromium in and of itself that should trigger regulation, regardless of whether it is in general industry, construction or maritime. Equal levels of exposure should lead to equal levels of cancer and, so, there should be an equal level of protection across all industries. Despite a recommendation from the Advisory Committee for Construction Safety and Health that the construction industries be included with general industry under a single standard, OSHA has proposed separate standards for general industry, construction and maritime. (The Maritime Advisory Committee for Occupational Safety and Health recommended a separate standard for maritime.)

Unlike the more stringent requirements of the general industry standard, the standards for construction and maritime will require no exposure monitoring (and hence no action level), will require medical surveillance only for those with signs or symptoms consistent with hexavalent chromium exposure (in general industry, exposures over the PEL often trigger the requirement for such surveillance), and will not require employers to maintain "regulated areas" (restricted-access areas known or expected to have exposures exceeding the PEL). Somehow employers in the construction and maritime industries are expected to meet the PEL even without being required to conduct initial, let alone intermittent, exposure monitoring. At the hearing, Dr. Schulte of NIOSH stressed the importance of exposure monitoring: "Adding an action level to the construction and maritime standards would enhance the protection provided to workers, and would provide an [additional] trigger for medical surveillance coverage, exposure monitoring, and other measures, such as personal protective equipment that may be needed to protect the health of workers."[106]

When asked why NIOSH believes exposure assessment requirements should be included for construction and maritime, Dr. Middendorf of NIOSH answered: "The reason for that is because personal breathing zone sampling is the traditional method for identifying jobs and tasks that need risk management. It really provides the most accurate determination of exposures. It is also an effective method for determining the effectiveness of controls and whether alternatives are needed. It has also traditionally been used and can be effectively used as a trigger for additional training, medical surveillance, and also periodic exposure monitoring."[107] In the absence of monitoring, these benefits will not be fully realized. Mr. Gillen of NIOSH added that "because there is a likelihood of higher exposures in construction, it is important to have exposure assessment." He agreed that this would also be the case for maritime.[108]

To our knowledge, this is the first time that OSHA has employed so irrational an approach to exposure reduction. At the recent hearing, Mr. Kojola of the AFL-CIO testified, "I think the fact that OSHA has not proposed to include an exposure assessment or exposure monitoring provision for the construction and the maritime industries is a departure from their typically -- typical response." He then goes on to state that this is "a major fault in the proposal, and we certainly would hope and, indeed, expect that OSHA will institute in its final rule some requirements for employers in the construction and the maritime

industries to do some exposure assessment."[109] At the recent hearing, Ms. Woodhull of ORC, the industry consulting group, agreed that monitoring should be done for all three sectors.[110]

Many aspects of the proposed standard for general industry are dependent upon monitoring. The absence of a monitoring requirement thus effectively guts the construction and maritime standards. In the recent hearing, OSHA's Ms. Edens explained that the rationale for this separate standard was "not based upon any medical need, because after all, the medical needs are the same … We were trying to relieve the burden of exposure monitoring in these two industry sectors."[111] In other words, the rationale is based on the agency's desire to not conduct exposure monitoring in maritime and construction. This seems to be backward reasoning, starting from the desired result of relieving the burden of exposure monitoring for two industries, instead of from the legal requirement to base regulation on the scientific data and health risks.

Although industry has questioned the feasibility of exposure monitoring for construction and maritime, various witnesses at the hearing noted that such monitoring already takes place for lead and asbestos. Ms. Susi, of the Center to Promote Workers Rights/United Association of Ironworkers testified that from a feasibility point of view there is no inherent obstacle to conducting airborne exposure monitoring on a construction site.[112] Mr. Kojola of the AFL-CIO also agreed that there is no reason why it would be difficult or impractical to do exposure monitoring for hexavalent chromium in both the construction and maritime industries.[113] Mr. Gillen of NIOSH concurred and stated, "There are challenges, but we really don't see that this is any more challenging than it is to do exposure assessment in general for construction."[114] When asked if there were any reasons why exposure assessment could not be done in construction or maritime, he went on to say that NIOSH was not "able to identify any reasons."[115] He then agreed that in other OSHA comprehensive health standards, exposure assessment for construction and maritime is typically included. Even construction industry representatives testified that they can and do conduct air monitoring for compliance with other standards such as lead and asbestos.[116]

Medical Surveillance

In NIOSH's testimony at the hearing, Dr. Schulte stated that the current proposal, which involves "shifting the responsibility for diagnosis of signs and symptoms of exposure to workers would be a departure from long-established public health practice … NIOSH suggests an action level trigger as opposed to a PEL trigger, because there is significant risk of lung cancer at the proposed PEL, and an exposure concentration has not been identified below which respiratory or dermal adverse health effects of occupational hexavalent chromium exposure do not occur."[117] Mr. Kojola of the AFL-CIO agreed that the medical surveillance proposed was a "significant departure from previous OSHA practices" and in effect provided workers with a lower level of protection.[118] If all industries are held to the same standard and required to do exposure monitoring, there would be no need for medical surveillance based on symptoms in the construction and maritime industries.

Procedural Issues

A consistent refrain from industry has been that there has been inadequate opportunity to make their concerns heard. This is a preposterous claim if one looks at the long and drawn-out history of the proposed hexavalent chromium regulation. For example, at the hearing Mr. Merritt of CPMA testified that CPMA was aware of the 1993 petition filed by Public Citizen and that it went to court as an intervenor in 1997 when Public Citizen/OCAW sued OSHA. When OSHA issued a request for information with respect to possible rulemaking on hexavalent chromium, CPMA submitted comments to the record. Finally, when Public Citizen filed a lawsuit in 2002, CPMA again intervened in the lawsuit.[119] Mr. Robinson acknowledged that the CPMA had made very similar scientific arguments in those proceedings to the ones it is now making. Hence, at numerous points over the course of the last 13 years, CPMA has availed itself of the opportunity to make its claims heard publicly, including two times in lawsuits. Other industry groups, including the "Chrome Coalition" similarly have long known of the pendency of the issue and have availed themselves of the opportunity to participate not only in the litigation but throughout the regulatory process (including the SBREFA process).

New Luippold study

Just as it appeared that all cohort studies on hexavalent chromium were in the record, Luippold published a new study this month in the Journal of Occupational and Environmental Medicine.[120] We feel that the study is seriously flawed and does not provide any useful data on the risks of hexavalent chromium. The study can not be used as a basis for a risk assessment because the exposure data are presented in the aggregate and not for particular individuals. Hence, it is impossible to relate cumulative hexavalent chromium exposure to risk for lung cancer.

As illustrated in Appendix 3, the Gibb study is superior to the new Luippold study in almost every respect. Even the old Luippold study, with its many flaws, is superior.

The Gibb study has four times more workers, seven times more person-years of follow up, forty times as many lung cancer deaths, and over ten times as many exposure measurements (that were more randomly obtained) than the new Luippold study. The old Luippold study has seventeen times as many lung cancer deaths and at least an additional 10 years of follow up. Thus, in essentially every measure, the new Luippold study is significantly inferior to Gibb and in critical respects to the old Luippold study as well.

Every research study assessing an occupational hazard seeks to identify an appropriate control group, be it a national, state or city control. A sign that the appropriate control group has been selected is that the "all cause" mortality is similar in the exposure and comparison cohorts, meaning that that the SMR is around one. However, in this new Luippold study, the SMR for all causes combined is 0.59, as it is for diseases of the heart.[121] The study cohort and the control group are clearly not comparable, with the most

likely explanation being the healthy worker effect. Without an appropriate control group as a valid comparison, the SMRs for all other diseases are uninterpretable.

In addition, this study lacks the necessary statistical power. Given that the expected number of lung cancer deaths is a paltry 3.75,[122] one would need a minimum of nine lung cancer deaths in order to show statistical significance based upon a Poisson distribution. This would mean an SMR of 2.4 (9/3.75). But even in the highest quartile of the Gibb study, the SMR is only 2.24.[123] Given that the point of the second Luippold study is to describe the impact of low hexavalent chromium exposures (0.36 to 4.36 ug/m^3), a study that is underpowered to detect an increase in lung cancer even at the highest exposure level in Gibb is obviously statistically underpowered. In sum, this new study is flawed due to its lack of statistical power, an inappropriate control group and the short follow-up. The last-minute appearance of this extremely weak study suggests yet another attempt by industry to muddy the scientific waters.

Conclusion

The NPRM and the testimony at the hearing have made an overwhelming case for the need for a PEL of 1 ug/m^3 as well as the technological and economic feasibility of this PEL. In fact, the evidence is clear that a still lower PEL of 0.25 ug/m^3 is also technologically and economically feasible, and OSHA has already conceded that it is justified on health grounds. Electroplating and welding are the only significant industries for whom economic feasibility is even remotely an issue, and almost half these workers are already compliant with a PEL of 0.25 ug/m^3. OSHA has questioned the technological feasibility of a PEL lower than 1 ug/m^3 in hard chrome electroplating and certain welding operations. Only 0.4% of workers affected by this rulemaking are in the hard chrome electroplating industry, and 42% of those facilities currently have exposures below 0.25 ug/m^3. For arc welding, in concluding that a lower PEL is not feasible, OSHA has gone well beyond the data provided in its consultant's report and even then has provided only the flimsiest of justifications. Already about half these welders are in compliance with our proposed PEL.

Even if we were to concede that a PEL of 0.25 ug/m^3 is infeasible in these two sub-industries (which we do not), the legal analysis provided in these comments demonstrates that a requirement for respiratory protection for some workers in a minority of sub-industries is not a justification for failing to lower the PEL for all workers, as long as there remains residual significant health risk. In addition, exempting whole industrial sectors in a misplaced effort to reduce the compliance burden for employers is in fact a transfer of a health burden to American workers.

With this proceeding entering its 13th year, and with the hearing and the NPRM having exposed the industry counter-arguments as essentially groundless, the time has come to adopt the 0.25 ug/m^3 PEL that workers require and that the science supports.

Yours sincerely,

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Appendix 1: Exposure profiles for 6 industries in which a PEL of 0.25 ug/m^3 would create annual costs greater than 1% of revenues.

Industry	Percent of Revenue [1]	Number of workers in industry	Percent of workers with current exposures (number of workers)		
			< 0.25 ug/m^3	0.25 – 1 ug/m^3	> 1 ug/m^3
Electroplating – general industry	1.75	11,684	64% (7478)	6% (701)	30% (3505)
Welding – construction industry	1.5	60,450	36% (22215)	20% (12241)	44% (25994)
Painting – general industry	2.54	6817	45% (3068)	24% (1636)	31% (2113)
Chromate (chromite ore production)	1.42	150	60% (90)	32% (48)	8% (12)
Chromium catalysts producers	1.27	313	40% (127)	18% (56)	52% (130)
Chromium catalysts users – service companies	1.15	707	17% (119)	50% (350)	34% (238)
Total		**80,121**	**41% (33,097)**	**19% (15,032)**	**40% (31,992)**

[1] Percent of annual revenue to comply with PEL of 0.25 ug/m^3

Appendix 2: Need for personal protective equipment (PPE) by industry and possible PEL (X = some workers need PPE to reach that PEL)

Industry	0.25 ug/m^3	0.5 ug/m^3	1 ug/m^3	>1 ug/m^3
1. Electroplating				
Hard chrome only	X	X	X	
Job-shop chrome platers	X	X	X	
Captive-shop chrome plater	X	X	X	
Job-shop plater	X	X	X	
Captive-shop plater	X	X	X	
Operator	X	X		
Helper/Other	X	X	X	
2. Welding				
General Industry				
SMAW[1] and GMAW[2] welding stainless steel in confined spaces	X	X	X	X
SMAW welding stainless steel and chromium alloys with 10% or more chromium in open shops	X	X	X	
SMAW	X			
GMAW	X			
Maritime				
SMAW wearfacing stainless steel in open shops	X	X	X	
SMAW welding various chromium alloys and stainless steel in open shops	X			
SMAW welding various chromium alloys and stainless steel in an enclosed area	X			
SMAW welding greater than 80% of metal as stainless steel or greater than 20% chromium alloy	X			
All welding/cutting exposures	X			
Construction (including government)				
SMAW welding stainless steel in confined spaces	X	X	X	X
Metallizing with alloys that contain 1% or more chromium in confined spaces	X	X	X	X
Brazing stainless steel in open shop areas	X	X	X	X
SMAW welding stainless steel in open shops	X	X		
3. Painting				
General Industry				
Painting small parts in a spray booth using an HVLP or electrostatic spray gun	X			

Industry	0.25 ug/m^3	0.5 ug/m^3	1 ug/m^3	>1 ug/m^3
Spray painting interior surfaces of an enclosed space	X	X	X	X
Abrasive blasting parts covered with hexavalent chromium-containing paint in a ventilated abrasive blast booth.	X	X	X	
Maritime				
Abrasive blasters	X	X	X	
Construction (including government)				
Laborers	X	X		
Spray painters performing abrasive blasting	X			
4. Producers of Chromates and Related Chemicals From Chromite Ore				
Chromic acid packaging operator	X	X	X	
Oxide 4 operator	X			
Railcar loader	X			
Evaporator operators	X			
Shift mechanics	X			
Kiln operators	X			
Maintenance workers in the kiln area	X			
5. Chromate Pigment Production				
Maintenance workers	X	X	X	
Managers/supervisors	X	X	X	
Proprietary process operators	X			
Dispersion operators	X			
Strike tank operators	X			
6. Chromated Copper Arsenate Producers				
Production operators	X			
7. Chromium Catalyst Production				
Lead operator	X	X	X	
Wet-process operator	X	X	X	
Dry-process operator	X	X	X	
Solid-waste handlers	X	X	X	
Forming operator (improved housekeeping)	X	X		
Floor person	X			
8. Paint and Coatings Production				
9. Printing Ink Producers				
Batch weighers	X			
Maintenance workers	X			
10. Plastic Colorant Producers and Users				
11. Plating Mixture Production				

Industry	0.25 ug/m^3	0.5 ug/m^3	1 ug/m^3	>1 ug/m^3
12. Wood Preserving				
13. Ferrochromium Alloy and Chromium Metal Production				
Plate hooker	X			
14. Steel Mills				
15. lron and Steel Foundries				
Torch cutter/gouger	X			
Welder	X			
16. Chromium Dioxide Producers				
17. Chromium Dye Producers				
Color makers	X			
Maintenance workers	X	X	X	
Managers/supervisors	X	X	X	
18. Chromium Sulfate Producers				
19.0 Chemical Distributors				
20.0 Textile Dyeing				
21.0 Producers Of Colored Glass				
22.0 Printing				
23.0 Leather Tanning				
24.0 Chromium Catalyst Users				
Process operators, all catalyst plants except Phillips polyethylene plants	X	X		
Field technicians, Catalyst service companies	X	X		
25.0 Producers Of Refractory Brick				
26.0 Woodworking				
27.0 Solid Waste Incineration				
28.0 Oil And Gas Well Drilling				
29.0 Portland Cement Producers				
30.0 Nonferrous Superalloy Producers And Users				
Welder	X	X		
31.0 Construction				
31.3.2.2.6 Refractory restoration and maintenance				
31.3.3.2.6 Hazardous waste site work	X			
31.3.4.2.6 Industrial rehabilitation and maintenance				
32.0 Producers Of Pre-Cast Concrete Products				

[1] SMAW – Shielded Metal Arc Welding, the most common welding process used.
[2] GMAW- Gas Metal Arc Welding, the second most common type of welding.

Appendix 3: Comparison of the Gibb, Luippold and New Luippold studies

	Gibb Study	**Luippold Study (2002)**	**New Luippold Study (2005)**
Workers	2,357	482	617
Person-years of follow-up	70,736	14,048	9,906
Duration of follow-up (years)	Mean: 30	Mean: 30.4	Mean Plant 1: 20 Mean Plant 2: 10
Loss to follow-up	0%	10%	1%
Lung cancer deaths	122	51	3
Exposure data collection	Routine	Industrial hygiene surveys	Industrial hygiene sampling
Exposure measurements	~70,000	>800	6,430
Includes low exposures?	Yes	No	Yes, but all aggregated
Smoking assessment	93% of cohort	35% of cohort	88% of cohort

[1] Gibb HJ, Lees PSJ, Pinsky PF, Rooney BC. Lung cancer among workers in chromium chemical production. American Journal of Industrial Medicine 2000;38:115-26.
[2] The Luippold data produce an estimate of 101 excess lung cancer deaths (95% CI: 62-147) per 1,000 lifetime workers under these conditions.
[3] The Luippold data produce an estimate of 2.1 excess lung cancer deaths (95% CI: 1.2-3.1) per 1,000 lifetime workers under these conditions.
[4] Herman Gibb, Ph.D., OSHA expert witness, Sciences International, Incorporated. Testimony at OSHA hexavalent chromium hearing. February 1, 2005 (Exhibit 44-4 Dr. Herman Gibb, pg 131).
[5] Bill Kojola, Industrial Hygienist, Department of Occupational Safety and Health, AFL-CIO. Testimony at OSHA hexavalent chromium hearing. February 8, 2005 (Exhibit 44-14, pg 1116-7).
[6] 69 Fed Reg 59391, October 4, 2004.
[7] Industrial Union Department, AFL-CIO v. American Petroleum Institute, 448 U.S. 607 (1980).
[8] The Luippold data produce an estimate of 1.0 excess lung cancer deaths (95% CI: 0.62-1.6) per 1,000 lifetime workers at a PEL of 0.5 ug/m^3.
[9] 69 Fed Reg 59312, October 4, 2004
[10] As pointed out by Mr. Kojola, "There's nothing in the benzene decision that prohibits OSHA from establishing a PEL that goes below one in a thousand risk for developing or dying of some form of cancer over a working lifetime." Bill Kojola. Industrial Hygienist, Department of Occupational Safety and Health, AFL-CIO. Testimony at OSHA hexavalent chromium hearing. February 7, 2005 (pg 727-8).
[11] Paul Schulte, Ph.D., Director, Education and Information, NIOSH, Public Participant. Testimony at OSHA hexavalent chromium hearing. February 2, 2005 (Exhibit 44-7, pg 314-5).
[12] Luippold RS, Mundt KA, Austin RP, et al. Lung cancer mortality among chromate production workers. Occupational and Environmental Medicine 2003;60:451-7.
[13] *See* Comments of the Surface Finishing Industry Council, Ex. 38-265-1, at 27-29.
[14] Luippold RS, Mundt KA, Austin RP, et al. Lung cancer mortality among chromate production workers. Occupational and Environmental Medicine 2003;60:451-7.
[15] Stuart Sessions, Environomics, Inc. Testimony at OSHA hexavalent chromium hearing. February 15, 2005 (Exhibit 44-40, pg 2418-21).
[16] Deborah Proctor, Aerospace Industry Association of America. Testimony at OSHA hexavalent chromium hearing. February 11, 2005 (pg 1845, 1849-51).
[17] Stuart Sessions, Environomics, Inc. Testimony at OSHA hexavalent chromium hearing. February 15, 2005 (Exhibit 44-40, pg 2430-33).
[18] Gibb HJ, Lees PSJ, Pinsky PF, Rooney BC. Lung cancer among workers in chromium chemical production. American Journal of Industrial Medicine 2000;38:115-26.
[19] Luippold RS, Mundt KA, Austin RP, et al. Lung cancer mortality among chromate production workers. Occupational and Environmental Medicine 2003;60:451-7.
[20] Public Citizen's Comments on OSHA's Proposed Rule on hexavalent chromium (HRG Publication #1717). Jan 3, 2005. Available at: http://www.citizen.org/publications/release.cfm?ID=7354&secID =1164&catID=126.
[21] Herman Gibb, Ph.D., OSHA expert witness; Sciences International, Incorporated. Testimony at OSHA hexavalent chromium hearing. February 1, 2005 (Exhibit 44-4 , pg 124).
[22] Herman Gibb Ph.D., OSHA expert witness; Sciences International, Incorporated. Testimony at OSHA hexavalent chromium hearing. February 1, 2005. (Exhibit 44-4, pg 121, 124, 129).
[23] Robert Park, Ph.D., NIOSH; public participant and Paul Schulte, Ph.D., Director, Education and Information, NIOSH, Public Participant. Testimony at OSHA hexavalent chromium hearing. February 2, 2005. (Exhibit 44-7, pg 312-4).
[24] Peter Lurie, MD, MPH; Public Citizen. Testimony at OSHA hexavalent chromium hearing. February 7, 2005 (pg 769-70).
[25] *E.g.*, Comments of the Surface Finishing Industry Council, Ex. 38-265-1, at 27 (Jan. 3, 2005); Deborah Proctor, Aerospace Industry Association of America. Testimony at OSHA hexavalent chromium hearing. February 11, 2005 (pg 1823, 1829-33, 1855-56).
[26] Herman Gibb,Ph.D., OSHA expert witness, Sciences International, Incorporated. Testimony at OSHA hexavalent chromium hearing. February 1, 2005 (Exhibit 44-4 , pg 103).

[27] Statement of Herman Gibb, Ex. 42-1, at 6.
[28] Statement of Herman Gibb, Ex. 42-1, at 2-5.
[29] Gibb HJ, Lees PS, Pinsky PF, Rooney BC**.** Clinical Findings of Irritation Among Chromium Chemical Workers, 38 Am. J. Indus. Med. 127, 129 (2000). (Table I).
[30] *See* Testimony at OSHA hexavalent chromium hearing. February 11, 2005, pg. 1855-56 (Mr. Shaeffer: "The fact is, if you take the mean cumulative exposure or the median cumulative exposure, which is available in this paper … [a]nd the mean median duration which they were exposed and do a rough calculation, do you come up with a really high exposure level, air level? I'll tell you, you don't, okay. It's quite a bit lower than the current OSHA [PEL].").
[31] *See* Ex. 35-395
[32] Post-hearing comments of Herman Gibb, Ex. 47-8, at 2 (March 21, 2005).
[33] Val Schaeffer, Ph.D., Toxicologist, Office of Chemical Hazards – Metals, OSHA. Testimony at OSHA hexavalent chromium hearing. February 1, 2005 (pg 59).
[34] Val Schaeffer, Ph.D., Toxicologist, Office of Chemical Hazards – Metals, OSHA. Testimony at OSHA hexavalent chromium hearing. February 1, 2005 (pg 60).
[35] 69 Fed Reg 59382, October 4, 2004.
[36] Harvey Clewell, Ph.D., Environ Health Sciences Institute. Testimony at OSHA hexavalent chromium hearing. February 1, 2005 (Exhibit 44-5, pg 185-6).
[37] Harvey Clewell, Ph.D., Environ Health Sciences Institute. Testimony at OSHA hexavalent chromium hearing. February 1, 2005 (Exhibit 44-5, pg 189).
[38] Val Schaeffer, Ph.D., Toxicologist, Office of Chemical Hazards – Metals, OSHA. Testimony at OSHA hexavalent chromium hearing. February 1, 2005 (pg 60).
[39] Herman Gibb, Ph.D., Sciences International, Incorporated. Testimony at OSHA hexavalent chromium hearing. February 1, 2005 Exhibit 44-4, pg 121).
[40] Lee Petsonk, M.D., NIOSH; public participant. Testimony at OSHA hexavalent chromium hearing. February 2, 2005 (Exhibit 44-7, pg 314).
[41] Joan Fessler. Carpenter Technology Corporation, Specialty Steel Industry of North American (SSINA). Testimony at OSHA hexavalent chromium hearing. February 4, 2005 (pg 678-9).
[42] Deborah Proctor, Aerospace Industry Association of America. Testimony at OSHA hexavalent chromium hearing. February 11, 2005 (pg 1846).
[43] Deborah Proctor, Aerospace Industry Association of America. Testimony at OSHA hexavalent chromium hearing. February 11, 2005 (pg 1846).
[44] Luippold RS, Mundt KA, Austin RP, et al. Lung cancer mortality among chromate production workers. Occupational and Environmental Medicine 2003;60:451-7.
[45] Post-hearing comments of NIOSH on the OSHA Proposed Rule occupational exposure to hexavalent chromium. Docket H054A, Ex 47-19-1, pg 7.
[46] 69 Fed Reg 59344, October 4, 2004.
[47] US Environmental Protection Agency. Health assessment document for chromium. Environmental Criteria and Assessment Office, Research Triangle Park, NC, 1984 (US EPA-600/8-83-014).
[48] Millar JD, Schulte PA. Testimony of The National Institute for Occupational Safety and Health on the Occupational Safety and Health Administration's Proposed Rule on Air Contaminants. August 1, 1988.
[49] International Agency for Research on Cancer. IARC monographs on the evaluation of carcinogenic risks to humans, chromium, nickel and welding. 1990;49:49-256. Lyons, France, World Health Organization.
50 Dr. Peter Marr, Dominion Colour Corporation. Testimony at OSHA hexavalent chromium hearing. February 11, 2005 (pg 1758-9).
[51] Docket H054A, Ex. 38-205. CPMA comments on the proposed rule for occupational exposure to hexavalent chromium, pg 102.
[52] Jeff Cox, Dominion Colour Corporation. Testimony at OSHA hexavalent chromium hearing. February 11, 2005 (pg 1736-7).
[53] Harvey Clewell, Ph.D., Environ Health Sciences Institute; Testimony at OSHA hexavalent chromium hearing. February 1, 2005 (Exhibit 44-5 Harvey Clewell, Ph.D., pg 161).
[54] Deborah Proctor, Aerospace Industry Association of America. Testimony at OSHA hexavalent chromium hearing. February 11, 2005 (pg 1834).

[55] Val Schaeffer, Ph.D., Toxicologist, Office of Chemical Hazards – Metals, OSHA. Testimony at OSHA hexavalent chromium hearing. February 1, 2005 (pg 69-70).
[56] Dee Woodhull Consultant, ORC World Wide. Testimony at OSHA hexavalent chromium hearing. February 8, 2005 (Exhibit 44-13, pg 1072-3).
[57] Paul Schulte, Ph.D, Director, Education and Information, NIOSH Public Participant. Testimony at OSHA hexavalent chromium hearing. February 2, 2005 (Exhibit 44-7, pg 310-11).
[58] Post-hearing comments of NIOSH on the OSHA Proposed Rule occupational exposure to hexavalent chromium. Docket H054A, Ex 47-19-1, pg 4.
[59] Jeff Cox, Dominion Colour Corporation; J. Lawrence Robinson, Color Pigments Manufacturers Association, Inc.; and H. Allen Irish, Esq, Counsel for NPCA. Testimony at OSHA hexavalent chromium hearing. February 11, 2005 (pg 1797, 1801, 1889).
[60] Steven Sides, National Paint and Coatings Association. Testimony at OSHA hexavalent chromium hearing. February 11, 2005 (pg 1887-1900).
[61] National Paint and Coatings Association. Testimony at OSHA hexavalent chromium hearing. February 11, 2005 (pg 1903).
[62] 69 Fed Reg 59452, October 4, 2004.
[63] 69 Fed Reg 59406-59407, October 4, 2004.
[64] Craig Colton. 3M Occupational Health and Environmental Safety Division. Testimony at OSHA hexavalent chromium hearing. February 10, 2005 (pg 1595-6).
[65] Frank White, Vice President, ORC World Wide. Testimony at OSHA hexavalent chromium hearing. February 8, 2005 (pg 1065).
[66] 69 Fed Reg 59420, October 4, 2004.
[67] Preliminary economic and initial regulatory flexibility analysis for OSHA's proposed standard for occupational exposure to hexavalent chromium. Docket H054A, Ex 35-391.
[68] Scott Throwe, U.S. Environmental Protection Agency. Testimony at OSHA hexavalent chromium hearing. February 3, 2005 (Exhibit 44-8, pg 417-8).
[69] Michael Wright, Director, of Health, Safety, and Environment, USWA. Testimony at OSHA hexavalent chromium hearing. February 15, 2005 (pg 2374-6).
[70] George Middleton, Residential construction industry. Testimony at OSHA hexavalent chromium hearing. February 9, 2005 (pg 1246-7); Thomas Heathmon, Concrete industry. Testimony at OSHA hexavalent chromium hearing. February 9, 2005 (pg 1403-4).
[71] James Stanley, Carbon steel industry. Testimony at OSHA hexavalent chromium hearing. February 14, 2005 (pg 2523-24 ; Bill Saas, Plating chemicals industry. Testimony at OSHA hexavalent chromium hearing. February 14, 2005 (pg 2192).
[72] Teresa Preston, Shipyard industry. Testimony at OSHA hexavalent chromium hearing. February 7, 2005 (pg. 904-912); Jack Waggener, Aerospace industry. Testimony at OSHA hexavalent chromium hearing. February 14, 2005 (pg 2236).
[73] Edison Electric Institute. Testimony at OSHA hexavalent chromium hearing. February 3, 2005 (pg. 454-56; power plants; industry representatives estimate costs but cannot testify to their significance in relationship to profits); Steve Shaver, Specialty Steel. Testimony at OSHA hexavalent chromium hearing. February 3, 2005 (pg. 619-621; witness testified that compliance costs might cause expansion plans to be put on hold, but could not identify any operations where compliance would be infeasible).
[74] We recognize that the CPMA's witnesses also testified that compliance by lead chromate production facilities would be infeasible, but since there are no such facilities in the U.S. that would be subject to the standard, that evidence is entirely irrelevant. Whether Canadian facilities could comply with the PEL is no concern of OSHA.
[75] Ken Hankinson, KCH Services, Inc. Testimony at OSHA hexavalent chromium hearing. February 14, 2005 (pg 2028-29).
[76] J. Kelly Mowry, Gull Industries, Inc. Testimony at OSHA hexavalent chromium hearing. February 14, 2005 (pg 2079-80).
[77] J. Kelly Mowry, Gull Industries, Inc. Testimony at OSHA hexavalent chromium hearing. February 14, 2005 (pg 2099; testimony of Mr. Mowry; acknowledging that existing controls already meet 10 ug/m^3).
[78] 69 Fed Reg 59407, October 4, 2004.

[79] Radha Krishnan, P.E. OSHA Expert Witness Shaw Environmental Incorporated. Testimony at OSHA hexavalent chromium hearing. February 2, 2005 (Exhibit 44-6, pg 250).
[80] Larry Verdier. Shaw Environmental Incorporated; OSHA Expert Witness. Testimony at OSHA hexavalent chromium hearing. February 2, 2005 (Exhibit 44-6, pg 269).
[81] Distribution of full shift personal hexavalent chromium exposures (8-hour TWA) for hexavalent chromium in general industry welding processes that are performed in all locations except confined spaces, based on combined data from NIOSH, private research and IMIS data; pg 2-34. Docket H054A Ex 35-390-6, Table 2-12b.
[82] Preliminary economic and initial regulatory flexibility analysis for OSHA's proposed standard for occupational exposure to hexavalent chromium, pg III-47. Docket H054A, Ex 35-391.
[83] Preliminary economic and initial regulatory flexibility analysis for OSHA's proposed standard for occupational exposure to hexavalent chromium, pg III-48. Docket H054A, Ex 35-391.
[84] Larry Verdier, Shaw Environmental Incorporated; OSHA Expert Witness. Testimony at OSHA hexavalent chromium hearing. February 2, 2005 (Exhibit 44-5, pg 267-8).
[85] 69 Fed Reg 59405, Table IX-2. October 4, 2004.
[86] 69 Fed Reg 59408, Table IX-3. October 4, 2004.
[87] 69 Fed Reg 59408, October 4, 2004.
[88] 69 Fed Reg 59406, Table IX-2, October 4, 2004
[89] 29 U.S.C. § 655(b)(5).
[90] *American Textile Mfrs. Inst. v. Donovan*, 452 U.S. 490, 509 (1981).
[91] *American Textile Mfrs. Inst. v. Donovan*, 452 U.S. 536 (1981).
[92] Similarly, OSHA has both substance-specific standards and a general respirator standard that require the use of respirators in some circumstances. Its statutory authority for those requirements is the same as its general authority to issue PELs. Thus, if respirators were somehow by definition "infeasible," all OSHA standards that require their use would be invalid.
[93] *Society of Plastics Indus., Inc. v. OSHA*, 509 F.2d 1301, 1310 (2d Cir. 1975).
[94] *Society of Plastics Indus., Inc. v. OSHA*, 509 F.2d at 1310 (2nd Cir. 1975).
[95] *United Steelworkers of America v. Marshall*, 647 F.2d 1189 (D.C. Cir. 1980).
[96] *United Steelworkers of America v. Marshall*, 647 F.2d 1272 (D.C. Cir. 1980).
[97] *United Steelworkers of America v. Marshall*, 647 F.2d 1272 (D.C. Cir. 1980).
[98] *United Steelworkers of America v. Marshall*, 647 F.2d 1280 (D.C. Cir. 1980).
[99] *United Steelworkers of America v. Marshall*, 647 F.2d. at 1285, 1286.
[100] *ASARCO, Inc. v. OSHA*, 746 F.2d 483 (9th Cir. 1984).
[101] *ASARCO, Inc. v. OSHA*, 746 F.2d 497 (9th Cir. 1984).
[102] *Building & Constr. Trades Dept., AFL-CIO v. Brock*, 838 F.2d 1258, 1267 (D.C. Cir. 1988).
[103] *Building & Constr. Trades Dept., AFL-CIO v. Brock*, 838 F.2d 1268 (D.C. Cir. 1988).
[104] *American Iron & Steel Institute v. OSHA*, 939 F.2d 973 (D.C. Cir. 1991).
[105] *American Iron & Steel Institute v. OSHA*, 939 F.2d at 990(D.C. Cir. 1991).
[106] Paul Schulte, Ph.D., Director, Education and Information, NIOSH. Testimony at OSHA hexavalent chromium hearing. February 2, 2005 (pg 300-1).
[107] Paul Middendorf, Ph.D., NIOSH; Testimony at OSHA hexavalent chromium hearing. February 2, 2005 (pg 304-5).
[108] Matt Gillen, CIH, NIOSH; Testimony at OSHA hexavalent chromium hearing. February 2, 2005 (pg 305).
[109] Bill Kojola, Industrial Hygienist, Department of Occupational Safety and Health, AFL-CIO. Testimony at OSHA hexavalent chromium hearing. February 8, 2005 (Exhibit 44-14, pg 1111-2).
[110] Dee Woodhull, Consultant, ORC World Wide. Testimony at OSHA hexavalent chromium hearing. February 8, 2005 (Exhibit 44-13: ORC World Wide testimony, pg 1080-1).
[111] Amanda Edens. Director, Office of Chemical Hazards – Metals, OSHA. Testimony at OSHA hexavalent chromium hearing. February 1, 2005 (Exhibit 44-3, pg 82).
[112] Pam Susi, CPWR/UA Ironworkers. Testimony at OSHA hexavalent chromium hearing. February 10, 2005 (pg 1487-8).
[113] Bill Kojola, Industrial Hygienist, Department of Occupational Safety and Health, AFL-CIO. Testimony at OSHA hexavalent chromium hearing. February 8, 2005 (Exhibit 44-14, pg 1115).

[114] Matt Gillen, CIH, NIOSH. Testimony at OSHA hexavalent chromium hearing. February 2, 2005 (pg 306).
[115] Matt Gillen, CIH, NIOSH. Testimony at OSHA hexavalent chromium hearing. February 2, 2005 (pg 307).
[116] George Middleton, National Association of Home Builders. Testimony at OSHA hexavalent chromium hearing. February 9, 2005 (pg 1249-50).
[117] Paul Schulte, Ph.D., Director, Education and Information, NIOSH. Testimony at OSHA hexavalent chromium hearing. February 2, 2005 (pg 301).
[118] Bill Kojola, Industrial Hygienist, Department of Occupational Safety and Health, AFL-CIO. Testimony at OSHA hexavalent chromium hearing. February 8, 2005 (Exhibit 44-14: AFL-CIO, pg 1115-6).
[119] Glenn Merritt, ESQ. Counsel for CPMA. Testimony at OSHA hexavalent chromium hearing. February 11, 2005 (pg 1766-9).
[120] Luippold RS, Mundt KA, Dell LD, Birk T. Low level hexavalent chromium exposure and rate of morality among US chromate production employees. J Occup Enviorn Med. 2005; 47:381-5.
[121] Luippold RS, Mundt KA, Dell LD, Birk T. Low level hexavalent chromium exposure and rate of morality among US chromate production employees. J Occup Enviorn Med. 2005; 47:381-5.
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