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OFFICE OF AIR QUALITY PLANNING AND STANDARDS
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SUBJECT: Residual Risk Test for Shipbuilding Source Category

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Introduction

This memo describes the methods and results of EPA's residual risk test for the shipbuilding and ship repair source category. The residual risk test is conducted by EPA at the beginning of the residual rule development process. It is EPA's intent that the test be completed quickly, usually within 1 to 3 months from the time the project starts. The purpose of the residual risk test is to determine, based on data already in EPA's possession and a relatively simple and protective (i.e., conservative) analysis, whether the source category can be shown at the outset *not* to require a residual risk rule. Under the requirements of the Clean Air Act Amendments of 1990, EPA will not promulgate additional emission standards for a source category if existing MACT standards provide an "ample margin of safety" for human health and are sufficient to prevent adverse environmental impacts (CAAA section 112(f)(2)(A)).

The residual risk test is not intended to be a complex or exhaustive assessment. It is, instead, an *a priori* attempt to determine if we already know enough to eliminate the source category as a source of further concern. A determination by EPA not to remove a source category from the residual risk process at this stage in no way suggests that a residual risk rule is inevitable, only that EPA lacks sufficient data at this time to forego such a rule.

The residual risk test in this case showed that EPA does not have sufficient data to remove the shipbuilding source category from consideration for a residual risk rule. EPA will therefore develop a data-gathering and analysis plan and obtain more refined data (e.g., on processes, emissions, emission control equipment, costs, etc.) for facilities in this source category. We will use these data to simultaneously refine our risk analysis and consider possible risk reduction options, the cost of those options, and other factors. EPA will use all these data when considering a residual risk rule, and may at any time determine that a rule is not necessary (e.g., because of low risk, infeasibility, low benefit-to-cost ratio, etc.).

Methods

1. Scope.

The residual risk test for the shipbuilding and ship repair source category focused solely on human health, estimating the emissions' potential to create chronic (i.e., 70-year) cancer and noncancer risks and acute (e.g., 1-hour) noncancer risks. Because health risk could not be eliminated as a concern, no assessment of potential impacts to environmental receptors was developed. The analysis included emissions associated with coating, cleaning, welding, cutting, and blasting operations.

2. Selection of HAPs and Dose-Response Information.

The residual risk test included all HAPs that were reported emitted by any of the ten facilities. These HAPs are listed in Table 1, with their respective chronic and acute dose-response assessment values. These values are described in more detail on EPA's Air Toxics Website at http://www.epa.gov/ttn/atw/toxsource/summary120202.html.

Table 1. Unit risk estimates[1], reference concentrations[2] (or similar values), and acute reference levels[3] used in the residual risk test for shipbuilding and ship repair.

HAP	URE 1/(µg/m^3)	RfC or similar value (µg/m^3)	ARL (µg/m^3)
Acetaldehyde	2.2E-06	9.0E+00	1.8E+04
Arsenic compounds	4.3E-03	3.0E-02	1.9E-01
Benzene	7.8E-06	6.0E+01	1.3E+03

[1]: Unit risk estimate (URE): The upper-bound excess lifetime cancer risk estimated to result from continuous exposure to an agent at a concentration of 1 µg/m^3 in air. The interpretation of unit risk would be as follows: if URE = 1.5 x 10-6 µg/m^3, 1.5 excess tumors are expected to develop per 1,000,000 people if exposed daily for a lifetime to 1 µg of the chemical in 1 m^3 of inhaled air. "Upper-bound" in this context is defined as a plausible upper limit to the true probability. An appropriate interpretation of upper-bound unit risk estimates is that the true value is probably less, and probably not greater.

[2]: Reference Concentration (RfC): An estimate (with uncertainty spanning perhaps an order of magnitude) of a continuous inhalation exposure to the human population (including sensitive subgroups) that is likely to be without an appreciable risk of deleterious effects during a lifetime.

[3]: Acute reference level (ARL): A short-term (e.g., 1-h) inhalation exposure to the human population estimated to cause only mild, reversible adverse effects, or no adverse effects. Because EPA has not developed either ARLs or guidelines for their derivation, ARLs were selected from a number of publically-available health effects reference values to assess "routine" acute or subchronic environmental exposures. These values were developed for slightly different purposes by different organizations, e.g., AEGLs, EPRGs and IDLH/10 address emergency situations often associated with industrial accidents while the more stringent RELs and MRLs address exposures of a non-emergency nature. Therefore, the intended uses and derivations of the reference values are not always directly comparable and may provide varying degrees of protection. For this reason, the ARLs should be regarded as less certain than either UREs or RfCs.

HAP	URE 1/(µg/m^3)	RfC or similar value (µg/m^3)	ARL (µg/m^3)
Beryllium compounds	2.4E-03	2.0E-02	2.5E+01
Cadmium compounds	1.8E-03	2.0E-02	9.0E+03
Carbon tetrachloride	1.5E-05	4.0E+01	7.5E+04
Chlorobenzene	–	1.0E+03	4.6E+05
Chromium compounds	1.2E-02[4]	1.0E-01	1.5E+03
Cobalt compounds	–	1.0E-01	2.0E+03
Dibutyl phthalate	–	–	4.0E+05
Ethylbenzene	–	1.0E+03	3.5E+05
Ethylene dichloride	2.6E-05	2.4E+03	2.0E+05
Ethylene glycol	–	4.0E+02	1.3E+03
Formaldehyde	1.3E-05	9.8E+00	9.4E+01
Glycol ethers	–	2.0E+01[5]	9.3E+01
Hexane	–	2.0E+02	3.9E+05
Lead compounds	1.2E-05	1.5E+03[6]	1.0E+04
Manganese compounds	–	5.0E-02	5.0E+04
Mercury compounds	–	3.0E-01	1.6E+03
Methanol	–	4.0E+03	6.9E+05
Methyl chloride	–	9.0E+01	1.0E+03
Methyl chloroform	–	1.0E+03	1.3E+06
Methyl ethyl ketone	–	1.0E+03	1.3E+04
Methyl isobutyl ketone	–	8.0E+01	–
Methylene chloride	4.7E-07	1.0E+03	1.4E+04
Nickel compounds	3.1E-04[7]	2.0E-01	1.0E+03
Phenol	–	2.0E+02	1.7E+04
Polycyclic organic matter	5.5E-05[8]	–	–
Tetrachloroethylene	5.9E-06	2.7E+02	2.4E+05

[4]: URE for hexavalent chromium.

[5]: RfC for most toxic glycol ether, diethylene glycol monobutyl ether.

[6]: National Ambient Air Quality Standard for lead.

[7]: Based on assumption that 65% of emitted nickel is insoluble, and 100% of insoluble nickel is crystalline.

[8]: Based on assumption the total POM mixture has 5% of the carcinogenic potentcy of benzo[a]pyrene.

HAP	URE 1/(µg/m^3)	RfC or similar value (µg/m^3)	ARL (µg/m^3)
Toluene	–	4.0E+02	3.1E+05
Trichloroethylene	2.0E-06	6.0E+02	5.4E+05
Xylenes (mixed isomers)	–	4.3E+02	5.6E+05

3. Dispersion Modeling for Chronic Exposures.

We selected the EPA Human Exposure Model (HEM) for the chronic portion of the residual risk test. The HEM contains (1) an atmospheric dispersion model with meteorological data, and (2) an exposure model based on U.S. Bureau of Census population data for 2000 at the census block level.

HEM's dispersion model is a Gaussian model based on the Industrial Source Complex Long Term model, ISCLT2, that has been simplified to improve computational efficiency. Necessary source-related inputs include map coordinates and height of the release, exit velocity, stack diameter, and temperature. Specifying the latitude and longitude of the facility calls the stability array (STAR) summary from the nearest meteorological station for use in the dispersion algorithm. The STAR data are standard climatological summaries (obtained from the National Climatic Center, Asheville, NC) formulated for use in EPA models. A STAR summary is a joint frequency-of-occurrence of wind speed, atmospheric stability, and wind direction, reflecting 5 years of data for 348 US sites.

The model produces polar coordinate receptor grid points consisting of 10 downwind distances (extending to 50 km) located along each of 16 radials. The dispersion model estimates concentrations for each of the 160 receptor locations on this grid. To simulate human exposure, the HEM relocates the ISCLT2 concentration estimates from their radial grid to centroids of population census blocks by interpolation (radially logarithmic and azimuthally arithmetic). The estimated ambient concentration at each census block centroid is presumed representative of people living in that block.

Annual site-specific emissions data were obtained from the 1999 National Emissions Inventory (NEI) and the most recent available Toxics Release Inventory (TRI). Data included yearly emission rates of HAPs and map coordinates for the ten largest emitters, in terms of tons per year, out of 396 facilities in the source category (of which approximately 40 were estimated to be major sources). Because the emissions data were self-reported by the individual facilities to the NEI and TRI, it is likely that the data were collected by a variety of methods. Use of different methodologies by different facilities may have resulted in inconsistencies in the emissions database used for the residual risk test.

Facility coordinates were verified through either the DeLorme Street Atlas or maps at www.topozone.com. Site-specific release parameters were not available for any facility, nor was information on activities performed at the site. In general, most of the emitted carcinogens were metals associated with welding operations. Therefore, welding was considered to be the preferred activity for modeling purposes, and the release parameters were selected to best represent this activity.

Although welding is considered an area source, emissions for each facility were modeled as a point source in order to permit the use of the HEM (which was developed primarily for major point sources). All emissions were assumed to occur at the drydock nearest to a populated area.

A sensitivity analysis was performed to determine the impact of the stack height input assumption. Heights of 6.15 (20'), 15.4 (50') and 24.6 (80') meters were considered. The stack height of 6.15m, and other release parameters shown below, were determined to best represent welding activities within a shipyard, based on comments from shipyard representatives (summarized in D. Reeves memo shown in Appendix A).

Stack height (meters)		6.15
Stack diameter (meters)		1.0
Stack gas exit velocity (m/sec)	0.1	
Stack gas temperature (K)		298
Building cross-sectional area (m^2)		100

Meteorology stability classes used in the HEM model were based on assumed urban land usage (i.e., significant amounts of cement and asphalt, which elevate temperatures during the day and cool more rapidly at night). These default model inputs will likely have represented some facilities better than others, so the accuracy of model outputs may vary among facilities.

The HEM allows only one dose-response value to be input per modeling run. To reduce the total number of necessary model runs, emissions of each HAP were adjusted to risk-equivalent tons of a single reference substance, using equation (1) for carcinogens and equation (2) for noncarcinogens.

$$CTPY = TPY_i \times \left[\frac{URE_i}{URE_R} \right] \qquad (1)$$

$$NTPY = TPY_i \times \left[\frac{RfC_R}{RfC_i} \right] \qquad (2)$$

Where:
- CTPY = Carcinogenic equivalent tons per year
- NTPY = Non-cancer equivalent tons per year
- TPY_i = Reported tons per year for HAP i
- URE_i = Unit risk estimate (URE) for HAP i
- URE_R = URE for the reference compound
- RfC_i = Reference concentration (RfC) or equivalent value for HAP i
- RfC_R = RfC or equivalent value for the reference compound

For this analysis we used a hypothetical reference compound with a URE of 1 $(\mu g/m^3)^{-1}$ and an RfC of 1 $\mu g/m^3$. Adjusted emission rates of each HAP were summed separately for carcinogens and

noncarcinogens, reflecting the default assumption that risks are additive across chemicals unless adequate evidence indicates otherwise. Emission rate adjustment reduced the number of model runs to two per facility (one each for cancer and chronic noncancer).

Lifetime cancer risk was estimated by multiplying the modeled highest ambient concentration in any census block by the URE of the reference compound. The hazard quotient (HQ) for noncancer effects was calculated by dividing the highest ambient concentration by the RfC of the reference compound. Since both the URE and the RfC were 1, the ambient concentrations of the cancer and noncancer model runs equaled the risk and HQ, respectively.

Because this procedure does not support separation of noncancer effects by target organ or toxic mechanism, the calculated HQ is really a hazard index (HI, defines as the sum of HQs for individual pollutants). In cases where effects of multiple noncarcinogens control the outcome of the residual risk test, additional target organ-specific model runs would be used to refine the assessment.

4. Dispersion Modeling for Acute Exposures.

For the acute exposure portion of the residual risk test, we used the SCREEN3 air dispersion model. SCREEN3 is a screening level gaussian dispersion model used to predict "worst-case" 1-hr concentrations on the centerline of the plume downwind from a source. The SCREEN3 model contains a set of wind speed and atmospheric stability combinations that are used to predict concentrations at user specified locations ranging from 100 meters to 5000 meters downwind from the source.

The acute analysis was based on the same annual site-specific emissions data and default release parameters used for the chronic analysis, and therefore carries the same uncertainties. To account for temporal variation in the short-term emission rates of the facilities, we additionally estimated that the maximum emission rate on an hourly basis could be as much as ten times the annual average hourly rate. Because the SCREEN3 model does not incorporate the HEM, the acute analysis did not consider population data, facility coordinates, or actual facility boundaries.

The acute analysis was based on a single SCREEN3 model run using the model's worst-case meteorology defaults, local flat terrain, and an assumed reference emission rate of 1 g/s. SCREEN3 calculates the ambient concentration per g/s of emissions for any substance, assuming no deposition or atmospheric reactions. For the purpose of estimating acute exposure, we considered it reasonable to assume an individual could spend an hour at the downwind point with the highest concentration (2435 $\mu g/m^3$ per g/s, at 100 m).

Annual emissions rates for each HAP at each facility were converted to maximum short-term emission rates using equation (3).

$$ER_{Max}(g/s) = ER_{Annual}(ton/y) \times 3.171E-08(y/s) \times 9.074E+5(g/ton) \times 10(Avg \rightarrow Max) \qquad (3)$$

Where: ER_{Max} = Maximum emission rate (g/s)

ER_{Annual}	=	Annual emission rate (tons/y)
Avg-Max	=	Tenfold conversion factor to simulate maximum short-term emission rate

The maximum downwind concentration for each HAP was calculated with equation (4).

$$C_{Max} = ER_{Max} \times C_{ref} \qquad (4)$$

Where:	C_{Max}	=	Maximum downwind concentration ($\mu g/m^3$)
	C_{ref}	=	Highest downwind concentration from SCREEN3 (2435 $\mu g/m^3$ per g/s)

The acute HQ for each HAP was calculated by dividing C_{Max} for each HAP by the appropriate ARL.

Results and Discussion

The cancer risk and chronic and acute HI estimates for the most-exposed census blocks for each facility are summarized in the Table 2. The estimates for chronic exposure represent individuals who actually live in the most impacted areas. The estimates for acute exposure are based on an individual who is assumed to spend one hour at the point of highest acute concentration.

It is important to note that these cancer risk and noncancer HI estimates are inherently protective. The cancer risk estimates represent a combination of "upper-bound" UREs (described in Table 1) and exposure estimates based partly on protective assumptions where data were absent. The true cancer risk is therefore probably less, and not likely to be greater. The chronic HI estimates are derived from the same exposure estimates as the cancer risks, combined with RfCs or similar dose-response values (Table 1) that are believed to be without adverse effects. It is possible that exposures above RfC levels would also not cause adverse effects. The acute HI estimates are based on a worst-case exposure scenario in combination with an exposure level thought to produce only mild, transient effects (or no effects; Table 1). This protective methodology translates to cancer risk and HI estimates that are unlikely to be exceeded in most of the exposed population, and that would likely decrease with more complete source and emissions data.

Table 2. Summary of results of the residual risk test for shipbuilding and ship repair.

Facility	Cancer Risk	Chronic HI	Acute HI	Risk Drivers
Avondale	2E-05	2.0	6.2	Cancer – 98% Cr Noncancer – 97% Mn Acute – 100% glycol ethers

Facility	Cancer Risk	Chronic HI	Acute HI	Risk Drivers
Bath Iron	1E-04	0.72	3E-04	Cancer – 98% Cr Noncancer – 80% Mn, 14% Cr Acute – NA
Cascade	1E-38	5E-04	7E-04	Cancer – NA Noncancer – NA Acute – NA
Electric Boat	4E-08	2E-06	2E-04	Cancer – NA Noncancer – NA Acute – NA
Ingalls	3E-05	0.21	1.1	Cancer – 96% Cr Noncancer – 74% Mn, 12% Cr, 10% Ni Acute – 80% methyl chloride, 14% ethylene glycol
Jeffboat	6E-05	11	0.17	Cancer – 97% Cr Noncancer – 99% Mn Acute – NA
Nassco	1E-05	0.47	7E-02	Cancer – 96% Cr Noncancer – 96% Mn Acute – NA
Newport	2E-05	0.76	0.17	Cancer – 75% Cr Noncancer – 91% Mn, 7% Ni Acute – NA
Norfolk	4E-09	3E-03	2E-03	Cancer – NA Noncancer – NA Acute – NA
Norshipco	7E-04	0.59	3E-02	Cancer – 100% Cr Noncancer – 99% Cr Acute – NA

Cancer risk estimates were dominated by chromium; noncancer HI estimates were dominated by manganese for chronic exposure, and glycol ethers for acute exposure.

Based upon our best scientific judgment we believe that acute exposures are generally not of concern for the shipbuilding source category. After considering available information for each of these pollutants, including the additional uncertainties involved in estimating acute risks using ARLs (i.e., values obtained from dose-response assessments developed by different agencies for different purposes, as per the footnote to Table 1), we have concluded that in the present case the hazard for reported emissions would not be of potential concern, except for those of glycol ethers, methylene

chloride, and ethylene glycol.

As discussed in the introduction, this analysis is not exhaustive and is not intended to be. We have used (1) the best emissions data currently available to us, (2) reasonable dispersion models, and (3) exposure locations where receptor populations currently reside or could be present to receive acute exposures. However, we applied several protective assumptions where data were absent, particularly regarding release locations and chromium speciation. On balance, using our scientific judgment and risk assessment experience, we believe the results are

protective, meaning the predicted risk estimates are likely higher than would be expected to actually occur in the exposed population.

Conclusions and Recommendations

Because these estimates suggest that at least some facilities may pose cancer risks greater than one in one million and noncancer hazard indexes greater than 0.2, we cannot recommend eliminating the shipbuilding and ship repair source category from consideration for a residual risk rule. We recommend instead that EPA pursue collecting additional data to inform the development of a possible residual risk rule for this source category. In particular, based on the results of our current assessment, we recommend that additional data gathering efforts consider the following:

- More accurate annual emissions rates for chromium, manganese, glycol ethers, methyl chloride, and ethylene glycol;
- Information on the ratio of hexavalent chromium to total chromium emitted;
- Information on the specific glycol ether compounds used;
- Site-specific release locations;
- Site-specific stack parameters;
- Maximum hourly emission rates for glycol ethers, methyl chloride, and ethylene glycol.

Documentation of input data used in the residual risk test is included in Appendix C (attached), an Excel spreadsheet with the following pages:

Data	Rough 1999 NTI/NEI data provided
Datasort	Data sorted by HAP
Total emissions	Emission rate and toxicity-equivalents calculations and values for cancer and noncancer
Total emissions summary	Emission rates used in HEM
HEM cancer inputs	Input data used for the cancer RR test
HEM non cancer inputs	Input data used for the noncancer RR test
Acute inputs and results	Emission rates used in SCREEN3, acute HI estimates
Attachments	
Appendix A	Emission Data provided by Coating & Consumer Products Group
Appendix B	Memo from Dave Reeves (EPA contractor) to Mohamed Serageldin,