

## **EPA's Metal Finishing Facility Risk Screening Tool (MFFRST) Status and Update**

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MFFRST was introduced at the 1999 AESF/EPA Conference. With specified or internally predicted emission rates of critical constituents (e.g.,  $\text{Cr}^{+6}$ ) into the work space and out of stacks into the ambient environment, it predicts the concentration of constituents in the air to which workers and nearby residents are exposed. Subsequent potential human health impacts are then estimated using traditional EPA methods. We produced and displayed a fully working version of MFFRST during the 2000 conference, and discussed updates and model validation exercises. During its two years of development, the MFFRST has undergone two rounds of peer review, and is now being finalized for release as an EPA product. Changes from the draft version will be discussed, as well as plans to finalize MFFRST, and to post the model and accompanying technical support documentation onto appropriate web sites. Plans will also be introduced for a "Version 2" that will include consideration of liquid and solid waste streams from metal finishing facilities.

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## Introduction

The Metal Finishing Facility Risk Screening Tool, or MFFRST, was developed to meet the objectives laid out during a March, 1998, meeting of the Common Sense Initiative Metal Finishing Subcommittee, Joint Risk Characterization and Research and Technology workgroup:

To develop a screening methodology that will enable characterizations of risks to workers and neighbors from emissions of single or multiple chemicals from metal finishing operations. In the future, field monitoring may be used to supplement and/or field test the methodology.

To develop a simple computer tool that will enable anyone without assistance to perform a screening characterization of the risks to workers and neighbors at metal finishing facilities.

MFFRST has met these objectives by providing a user-friendly, Windows-based software tool which predicts the air concentration of metal finishing constituents within metal finishing facilities and at nearby locations, and then interpreting these predicted air concentrations in terms of health risk assessment methodologies commonly employed by EPA.

This paper will: 1) provide an overview of MFFRST, 2) describe its history with an emphasis on the peer review cycles and EPA's response to review comments, 3) provide a demonstration of its usage to display its capabilities, and 4) discuss current and future plans for dissemination and possible further developmental work on MFFRST.

Discussions on the theoretical construct, model testing, and validation of certain portions of MFFRST have appeared in previous papers presented at the annual AESF/EPA conferences (Lorber, et al., 2000; Schwartz and Lorber, 2000; Lorber, et al., 1999; Schwartz and Lorber, 1999), and these details will not be repeated here. A companion paper to this one (Schwartz and Lorber, 2001) presents an important new validation of the model predicting emissions from metal finishing tanks.

## Model Overview

As a first step, MFFRST requires users to describe the "source" of metal finishing constituents. The sources could include: an existing facility which has reported stack emissions to the EPA Toxics Release Inventory (TRI) data base, a "generic" facility containing one or more metal plating lines, or known air concentrations of one or more metal finishing constituents (in which case the model would not predict air concentrations from known or predicted emissions). If the user chooses the "generic" facility option, MFFRST predicts the emissions of metal finishing constituents out of tanks, both as fugitive emissions into the workplace and as residual emissions into the ambient environment from stacks. These emissions are dispersed in the workplace and into the atmosphere, to reach the breathing zones of worker and nearby residential receptors. A prescribed set of behaviors of these receptors (inhalation rates, time of exposure, etc.) describes their inhalation exposure to these emitted constituents. Using traditional EPA methods for evaluating inhalation exposure and health risk, MFFRST displays the results of the simulations in summary tables.

MFFRST has been developed following these guiding principles:

1) *MFFRST will be easy to use for scientists, regulators, industry representatives, and members of the public:* A user-friendly interface allows users to describe the metal finishing facility and exposure circumstances they wish to evaluate. Users will have the capability of defining scenarios of interest through a series of parameter input screens, and then saving their scenario definitions for future retrieval.

2) *Complete sets of default input parameter sets will be provided.* Users will be able to model scenarios of interest by defining only the broadest of scenario characteristics, such as the metal plating line they wish to evaluate, whether to include both workers and residents or just one of these groups, and so on. On the other hand, they can begin from a broad definition, but then choose to alter any of the hundred or so parameters involved in a single scenario definition. They can alter site-specific parameters such the default plating tank characteristics, the fate modeling parameter values and assumptions, the extent of exposure, the constituent-specific health risk descriptors, and others. In this paper, we will provide a set of demonstration results which use all the default parameters. Providing default values places a high degree of responsibility on MFFRST users of this tool to understand the implications of their acceptance of defaults. In developing them, we have sought to assign values that are technically defensible, and that also are consistent with the next two objectives - to be consistent with accepted EPA methods and models, and to be consistent with goals for “screening-level” models.

3) *MFFRST uses tested and accepted EPA models for fate of tank-emitted constituents, and accepted EPA approaches for quantifying potential inhalation health risk based on air concentrations.* This project did not involve development of new modeling approaches for fate modeling of emitted constituents, or for evaluating the impact of inhalation exposures to these constituents. It did develop and test models for predicting emissions from metal finishing tanks.

4) *MFFRST is characterized as a “screening model”.* The word, “screening”, has two connotations in MFFRST: a) the fate algorithms use relatively simple models which require only a minimum of site-specific information, and b) conservative assumptions, such as no atmospheric degradation or transformations, are employed. Users may wish to employ more sophisticated air dispersion models to predict exposure point air concentrations, particularly if a health impact of concern is of an acute nature - MFFRST is designed to provide average concentrations that could occur at a specified point downwind of the facility, or within a work place. Also, if an intended use of MFFRST is to develop information that is used in a regulatory mode, users may wish to verify results from MFFRST with measurements or other models. “Screening” models in EPA are most often used for just that purpose - to “screen” for potential problems which can then be evaluated in more detail, using other models or actual field measurements.

## **Historical Overview and Peer Review of MFFRST**

EPA unveiled the Metal Finishing Facility Risk Screening Tool, MFFRST, during the 1999 AESF/EPA Conference for Environmental Excellence (Lorber, et al., 1999; Schwartz and Lorber, 1999). At that time, the proposed methodology and input data for MFFRST had been developed, but not installed into the software tool. A set of computer screens on display at an EPA Exhibit Booth gave individuals a sense of where the EPA was going with MFFRST. The fully installed tool was completed and available in time for display at the June, 1999 SURF/FIN® Conference. Based on public comments sought and received at both conferences from experts in the metal finishing industry, federal government (EPA, OSHA), state agencies, non-government organizations, consultants, and others, MFFRST was updated for presentation at the January, 2000 AESF/EPA Conference for Environmental Excellence (Lorber, et al., 2000; Schwartz and Lorber, 2000).

In March of 2000, a second round of peer review was initiated. A total of six individuals were sought to provide in-depth comments on both the software tool and the accompanying technical support document. These individuals were selected based on having providing helpful comments during the first round of MFFRST review (3 individuals) and also based on their unique expertise although they had not been involved in the previous MFFRST review (3 individuals). Four of these six have returned comments to EPA, which have been used to finalize MFFRST. Comments from these four individuals were in the areas of presentation/user-friendliness, technical validity of the models, industry characterization, and relevancy to one’s job:

Presentation/User-Friendliness: As in the first round of review of MFFRST, described in Lorber, et al. (2000), the second round reviewers generally found the model to be easy to use, with the input screens being reasonably self-explanatory. One of the reviewers did send in detailed suggestions for reconstruction of the first several screens of

MFFRST, which would clarify the intent of the initial decisions made by the user. The most important initial decision made by the user is a description of the “source” of the metal finishing constituents. Based on this reviewer’s comments, a user is now given four choices for source characterization: “1. Perform an assessment based on facility-specific emissions (TRI data). 2. Perform an assessment based on generic facility processes and emissions data 3. Perform an assessment based on user-defined facility process information, and 4. Perform an assessment based on available exposure concentration data.” Two other topics addressed by reviewers in this category are the use of graphical output, and the generation of variability/uncertainty results to go along with the current point estimates of results provided in MFFRST. While graphical output may increase the clarity and power of some of the possible output from MFFRST, the decision was made to remain solely with tabular outputs. We felt that given the variety and scope of the output, designing the proper display of results graphically would be an overwhelming task - users could externally create bar graphs, line graphs, pie charts, or other visual aids to present MFFRST results of personal interest. Regarding uncertainty and variability, one user felt strongly that the conservative nature of the point estimate results could lead to model misuse or misinterpretation of the results, and urged that procedures be developed to describe a range for MFFRST results which could account for variability and/or uncertainty. Others felt that point estimates were sufficient and appropriate, that the technical supporting document would be a place to appropriately discuss uncertainty and variability. We agreed with this latter opinion; the technical support document discusses uncertainty issues of concern in the generation of MFFRST results.

Technical Validity of the Data and Models: All reviewers supported the use of the TRI emissions in this tool as well as the use of SCREEN3 to model air dispersion of emitted constituents.

Industry Characterization: In addition to zinc chloride electroplating and zinc cyanide electroplating, an alkaline non-cyanide zinc electroplating generic line has been added to MFFRST. A silver plating line has also been added, raising the total of generic plating lines from 15 to 17. Additional changes were made to the generic metal plating lines, including the reconfiguration of some of the lines and the reassignment of a few default parameter values. For example, chromate dips were added to the zinc and cadmium plating lines. An example of a parameter change is that hexavalent chromium plating solutions were assumed to have a 15% cathode current efficiency, instead of the earlier assumed efficiency of 20%.

Relevancy to one’s job: One industry consultant thought the model would be very useful to his clients needs, whereas one EPA reviewer suggested it might be useful to him if he were employed by the plating industry. This would imply that MFFRST may find a broader audience in the industry rather than the regulatory sector. However, a second EPA reviewer did say that they have needs for the type of information generated by MFFRST, but that they currently use SCREEN3 and other tools to meet their needs.

## **Demonstration of MFFRST**

The purpose of this section is to briefly demonstrate, through a series of examples, the capabilities of MFFRST for evaluating the potential exposures and risks to workers and nearby residents.

### *1. Estimating Potential Health Risks Using TRI Facility-Specific Emissions Data*

This section presents example inputs and the resulting predicted exposures and risks for two metal-finishing plants whose emissions are profiled in TRI and within MFFRST. These two facilities were selected as examples because they demonstrate the range in both chemical types and amounts emitted from metal finishing facilities. They will be identified simply as Facility #1 and Facility #2. Although it is not possible to determine from the TRI and AIRS/AFS databases what specific processes are operative at these facilities, they both report emitting chromium compounds. The example facilities were selected because they emit more than one chemical with either appropriate cancer and non-cancer toxicity endpoints; such endpoints are not available for all constituents modeled to be emitted from tanks in MFFRST. In this way, the capability for predicting potential inhalation health impacts is demonstrated.

Table 1 shows key input parameters for these two facilities, including stack parameters necessary to run the SCREEN3 air dispersion model, the emission rates of the constituents as

**Table 1.** Input values for TRI facilities.

Input Assumptions	Facility #1	Facility #2
I. Stack Parameters		
Default or Specified Parameters?	Default	Reported in AIRS/AFS
Stack Height	25 ft	10 ft
Stack Exit Gas Velocity	35 ft/sec	35 ft/sec (default)
Stack Diameter	1.5 ft	1.3 ft.
Ambient Temp	70 F	70 F
Stack Exit Temp	80.6 F	78 F
Downwash?	No	No
II. Release rates of constituents, lbs/yr		
Chromium compounds	5.0 E+02	1.0 E+01
Copper compounds	5.0 E+02	1.0 E+01
Cyanide compounds	5.0 E+02	---
Ethylbenzene	—	8.35 E+03
Formaldehyde	---	3.35 E+03
Methyl Ethyl Ketone	---	2.08 E+05
Nickel compounds	5.0 E+02	1.0 E+01
Nitric acid	5.0 E+02	5.70 E+02
Toluene	---	4.46 E+04
Xylene (mixed isomers)	---	1.11 E+05
Zinc compounds	5.0	---
III. Exposure Parameters		
Surrounding Land Use	Urban	Urban
Distance to Residence	100 m	100 m
Meteorological Classification	Full	Full
Terrain Height	0 m	0 m
Years Exposed	30	30
Days Exposed per Year	350	350
Average Hours Exposed per Day	16	16
Inhalation Rate	1.25 m <sup>3</sup> /hour	1.25 m <sup>3</sup> /hour
Body Weight	70 kg	70 kg

reported in the 1997 TRI data base, and the exposure factors for the nearby resident. The stack parameter default values were chosen based on an analysis of between 623 and 894 site-specific metal finishing plant values from EPA's AIRS/AFS database. Facility-specific stack parameter data were not available in AIRS/AFS for Facility #1 and, therefore, default stack parameter values were used. Facility-specific stack parameter data were available in AIRS/AFS for most parameters for Facility #2. MFFRST will automatically use the AIRS/AFS values unless the user edits the values. Emission rates for the constituents are in units of pounds per year. As seen, there is a fifty-fold difference in the emission rates of chromium compounds between the facilities. MFFRST conservatively assumes that all chromium emissions, reported as "chromium compounds" in the TRI data base, are in the form of hexavalent chromium. The default exposure parameters demonstrate the conservative nature of MFFRST. Exposed residents are assumed to reside 100 meters from the facility. This assumption needn't be taken literally; equivalently, it means that concentrations to which nearby residents are exposed are those predicted by MFFRST to occur at 100 meters from the stack. Residents are assumed to be exposed for 30 years, 350 days/year, and 16 hr/day. They breathe an average of 1.25 m<sup>3</sup>/hr during these 16 hours. This is a normal rate of breathing; the other exposure parameters might be characterized as conservative.

Tables 2 and 3 show the results from MFFRST, including the predicted concentrations and the health impacts. The non-cancer health risks presented in Table 3 are characterized in terms of hazard quotients (HQs) and hazard indices (HIs). An HQ is the ratio of the predicted air concentration for a chemical to its Reference Concentration (RfC). The HI is the sum of the HQs for each chemical included in the risk characterization. If the HQ for a chemical equals or exceeds 1.00, then EPA would consider this to be a situation of potential health concern warranting further investigation. However, conservatism is built into the derivation of these non-cancer toxicity endpoints. An RfC is developed by EPA for chronic and sub-chronic non-cancer effects. In general, the chronic RfC is an estimate (with uncertainty spanning perhaps an order of magnitude) of a daily inhalation exposure of the human population (including sensitive subgroups) that is likely to be without an appreciable risk of deleterious non-cancer effects during a lifetime. The subchronic RfC is defined similarly as the chronic RfC, except the risk pertains to a portion of a lifetime rather than a full lifetime. Further details on these health risk procedures are provided in Lorber, et al. (1999). Referring to Table 3, the HIs for both facilities exceed 1.00, indicating potential for health impacts for receptors who live for 30 years at the point of highest maximum annual average concentration at a distance of 100 meters from the facilities. The HIs, 3.18E+01 and 1.82E+00, are due almost entirely to chromium compounds released by the facilities.

The cancer health risks presented in Table 3 are characterized as the probability of incurring cancer (not dying of cancer) over a lifetime, given the incremental exposure due to emissions from the nearby facilities. Cancer risks are calculated separately for each carcinogenic chemical and the individual chemical risks are then summed to generate a total risk for the facility. If the predicted cancer risk is greater than 1.00E-04, then EPA often considers this to be a situation of potential health concern warranting further investigation. This investigation could be in the form of a more detailed risk assessment. Such assessments could include further modeling using more site-specific information concerning locations and activity patterns of potential receptors, and even different, more refined, air dispersion models. Referring to Table 3, the total predicted facility risks exceeded 1.00E-04 for one facility and the predicted risk for that facility was due entirely to chromium compounds.

**Table 2.** Ambient air concentrations (mg/m<sup>3</sup>) predicted by MFFRST for the two TRI facilities.

Air Concentrations Predicted by MFFRST (mg/m <sup>3</sup> )	Facility #1	Facility #2
Chromium compounds	2.54 E-04	1.14 E-05
Copper compounds	2.54 E-04	1.14 E-05
Cyanide compounds	2.54 E-04	---
Ethylbenzene	---	9.52 E-03
Formaldehyde	---	3.82 E-03
Methyl Ethyl Ketone	---	2.37 E-01
Nickel compounds	2.54 E-04	1.14 E-05
Nitric acid	2.54 E-04	6.50 E-04
Toluene	---	5.09 E-02
Xylene (mixed isomers)	---	1.27 E-01
Zinc compounds	2.54 E-06	---

**Table 3.** Cancer and non-cancer health risk for residential receptors estimated by MFFRST for the two TRI facilities (NA = unit risk values or RfCs unavailable for these constituents).

Facility	Chemical	Air Concentration (mg/m <sup>3</sup> )	Non Cancer Toxicity Endpoint (RfC - mg/m <sup>3</sup> )	Hazard Quotients and Hazard Index	Unit Risk Value (m <sup>3</sup> /mg)	Cancer Risk
Facility #1	Chromium compounds	2.54 E-04	8.00 E-06	3.05 E+01	1.20 E+01	1.25 E-03
	Cyanide compounds	2.54 E-04	7.00 E-02	3.48 E-03	---	---
	Hazard Index, HI: 3.05 E+01				TOTAL: 1.25 E-03	
Facility #2	Chromium compounds	1.14 E-05	8.00 E-06	1.37 E+00	1.20 E+01	5.63 E-05
	Formaldehyde	3.82 E-03	---	---	1.3 E-02	2.04 E-05
	Ethylbenzene	9.52 E-03	1.00 E+00	9.13 E-03	NA	NA
	MEK	2.37 E-01	1.00 E+00	2.28 E-01	NA	NA
	Toluene	5.09 E-02	4.00 E-01	1.22 E-01	NA	NA
	Xylenes	1.27 E-01	7.00 E+00	1.74 E-02	NA	NA



	Hazard Index, HI: 1.74 E+00	TOTAL: 7.67 E-05
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It is emphasized that the results of this screening risk assessment do not necessarily imply that high risks are actually occurring. Rather, the results should be interpreted as an indication that further modeling and/or air monitoring may be needed to more accurately identify the potential risks.

## 2. Estimating Potential Health Risks Using a Generic Plating Line

The decorative chromium generic plating line will be demonstrated. It has eight tanks: 1) *alkaline cleaner*; 2) *electrocleaning*; 3) *acid etching #1*; 4) *copper strike*; 5) *copper plating*; 6) *acid etching #2*; 7) *nickel plating*; and 8) *hexavalent chromium plating*. The fate parameters estimating outdoor (using SCREEN3) and indoor (assuming a simple dispersion box model) air concentrations, and the exposure parameters, are provided in Table 4. The key parameters for estimating indoor air concentrations are: 1) the rate of 1% of uncontrolled emissions assumed to escape into the workplace environment, and 2) the building ventilation rate. The key parameter for exposure to the process worker is the amount of time exposed to the high concentrations of the uncontrolled emissions. The default assumption for MFFRST is 5% of a working day, or 0.4 hours out of an 8-hr work day.

Table 5 shows the uncontrolled and controlled emission rates for the several tanks in the generic plating line. The controlled emission rates are the rates of release from stacks into the ambient environment. The air concentrations in the workplace are a function of the uncontrolled emission rate, the fraction of uncontrolled emissions getting into the workplace (1%), and the ventilation rate of the workplace. It is important to note that the controlled emission rates from the generic line are much lower than the TRI emission rates. This was explored in an MFFRST paper presented at the AESF/EPA meeting in 2000 (Schwartz and Lorber, 2000). The release of hexavalent chromium out of the stack from a generic decorative chromium line, from Table 5, is 13.4 mg/day, which converts to 0.01 lbs/yr. This compares to the 500 and 10 lbs/yr of chromium compounds reported by the two facilities of the TRI data base demonstrated earlier.

Because of these much lower emission rates, the predicted air concentrations and subsequent health impacts to the nearby resident are much lower for the generic facilities as compared to the TRI facilities. Air concentrations to which workers and nearby residents are exposed to is provided in Table 6, and Table 7 shows the cancer and non-cancer health risk assessment results for the nearby resident. As seen in Table 7, the HI is on the order of  $10^{-4}$ , compared to HIs on the order of  $10^0$  and  $10^1$  for the TRI facility demonstration. The cancer risk is also four orders of magnitude lower for the resident in the generic line demonstration as compared to the TRI demonstration.

However, the impacts to the workplace and the potential health risk to the workers is significantly higher than for the nearby residents. As seen in Table 6, air concentrations for all the constituents are between 4 and 7 orders of magnitude higher indoors as compared to outdoors. Health impacts are shown in Table 8. The predicted average hexavalent chromium concentration of 0.0038 mg/m<sup>3</sup> for the non-process worker and 0.024 mg/m<sup>3</sup> for the process worker (with the

**Table 4.** Input values for the generic decorative chromium facility.

Input Assumptions	For the Adult Resident	For the Process and Non-Process Workers	
I. Stack Parameters and Indoor Parameters for Air Concentration Calculations			
Default or Specified Parameters?	Default	---	
Stack Height	25 ft	---	
Stack Exit Gas Velocity	35 ft/sec	---	
Stack Diameter	1.5 ft	---	
Ambient Temp	70 F	---	
Stack Exit Temp	80.6 F	---	
Downwash?	No	---	
Surrounding Land Use	Urban	---	
Distance to Residence	100 m	---	
Meteorological Classification	Full	---	
Terrain Height	0 m	---	
Percent of uncontrolled tank emissions escaping into workplace	---	1 %	
Ventilation rate	---	4.0 E+5 ft³/hr	
III. Exposure Parameters			
	Resident	Process Worker	Non-Process Worker
Years Exposed	30	30	40
Days Exposed per Year	350	250	250
Average Hours Exposed per Day	16	0.4 / 7.6 <sup>1</sup>	8
Inhalation Rate	1.25 m³/hour	1.25 m³/hour	1.25 m³/hour
Body Weight	70 kg	70 kg	70 kg

<sup>1</sup> For the process worker, 0.4 hours equals the amount of time that the process worker is assumed to be exposed to concentrations in the uncontrolled emissions. They are exposed to the average indoor air concentration for the remaining 7.6 hours of the work day.

**Table 5.** MFFRST modeled emission rates from a generic decorative chromium plating line (values in parentheses are emission rates assuming use of default pollution control technologies. Values not in parentheses are uncontrolled emission rates).

Chemicals Emitted from Decorative Chromium Plating Line	Estimated Emission Rates (mg/day)							
	Alkaline Cleaner (mg/day)	Electro- cleaning (mg/day)	Acid Etching (mg/day)	Copper Strike (mg/day)	Copper Plating (mg/day)	Acid Etching #2 (mg/day)	Nickel Plating (mg/day)	Hexavalent Chromium Plating (mg/day)
Sodium Phosphate	7.98 E+03 (1.65 E+02)	5.61 E+03 (1.16 E+02)	---	---	---	---	---	---
Sodium Hydroxide compounds	4.25 E+04 (8.79 E+02)	2.99 E+04 (6.19 E+02)	---	---	---	---	---	---
Sodium Metasilicate	1.33 E+04 (2.75 E+02)	9.36 E+03 (1.93 E+02)	---	---	---	---	---	---
Sulfuric Acid	---	---	1.71E+05 (7.30 E+03)	---	---	1.71 E+05 (7.3 E+03)	---	9.98 E+03 (1.30 E-01)
Copper	---	---	---	2.04 E+03 (9.13 E+00)	2.81 E+03 (1.25 E+01)	---	---	---
Cyanide	---	---	---	2.95E+03 (1.32 E+01)	4.21 E+03 (1.88 E+01)	---	---	---
Nickel	---	---	---	---	---	---	1.96 E+04 (8.74 E+02)	---
Boric Acid	---	---	---	---	---	---	9.65 E+03 (4.31 E+01)	---
Hexavalent Chromium	---	---	---	---	---	---	---	1.02 E+06 (1.33 E+01)

**Table 6.** MFFRST estimated predicted concentrations to which process workers, non-process workers, and nearby residents are exposed (mg/m<sup>3</sup>).

Chemicals Emitted from Decorative Chromium Plating Line	Process Worker	Non-Process Worker	Resident
Sodium Phosphate	1.1 E-3	5.0 E-5	1.2 E-7
Sodium Hydroxide compounds	6.1 E-3	2.3 E-4	6.1 E-7
Sodium Metasilicate	1.9 E-3	8.3 E-5	1.9 E-7
Sulfuric Acid	3.1 E-2	9.0 E-5	6.0 E-6
Copper	5.0 E-4	1.8 E-5	8.9 E-9
Cyanide	7.3 E-4	2.6 E-5	1.3 E-9
Nickel	6.6 E-4	7.2 E-5	3.6 E-8
Boric Acid	3.3 E-4	3.6 E-5	1.8 E-8
Hexavalent Chromium	2.4 E-2	3.8 E-3	5.4 E-9

**Table 7.** Cancer and non-cancer assessment results for the nearby resident for the generic decorative chromium plating line.

Chemicals Emitted from Decorative Chromium Plating Line	Concentration, mg/m <sup>3</sup>	Non Cancer Toxicity Endpoint (RfC - mg/m <sup>3</sup> )	Hazard Quotients and Hazard Index	Unit Risk Value (m <sup>3</sup> /mg)	Cancer Risk
Sodium Phosphate	1.2 E-7	---	---	---	---
Sodium Hydroxide compounds	6.1 E-7	---	---	---	---
Sodium Metasilicate	1.9 E-7	---	---	---	---
Sulfuric Acid	6.0 E-6	---	---	---	---
Copper	8.9 E-9	---	---	---	---
Cyanide	1.3 E-9	7.0 E-2	1.9 E-7	---	---
Nickel	3.6 E-8	---	---	---	---
Boric Acid	1.8 E-8	---	---	---	---
Hexavalent Chromium	5.4 E-9	8.0 E-6	6.8 E-4	1.2 E+1	2.7 E-8
		Hazard Index, HI: 6.8 E-4		TOTAL: 2.7 E-8	

**Table 8.** Health risk results for process and non-process workers for the generic decorative chromium plating line.

Chemicals Emitted from Decorative Chromium Plating Line	Concentration, mg/m <sup>3</sup>		Occupational Endpoints, mg/m <sup>3</sup>			Cancer Assessment		
	Process Worker	Non- Process Worker	PEL	TLV	REL	Unit Risk Value (m <sup>3</sup> /mg)	Process Worker	Non- Process Worker
Sodium Phosphate	1.1 E-3	5.0 E-5	---	---	---	---	---	---
Sodium Hydroxide compounds	6.1 E-3	2.7 E-4	2.0	---	---	---	---	---
Sodium Metasilicate	1.9 E-3	8.3 E-5	---	---	---	---	---	---
Sulfuric Acid	3.1 E-2	9.0 E-5	1.0	1.0	1.0	---	---	---
Copper	5.0 E-4	1.8 E-5	1.0	1.0	1.0	---	---	---
Cyanide	7.3 E-4	2.6 E-5	---	---	---	---	---	---
Nickel	6.6 E-4	7.2 E-5	1.0	1.0 E-1	1.5 E-2	---	---	---
Boric Acid	3.3 E-4	3.6 E-5	---	---	---	---	---	---
Hexavalent Chromium	2.4 E-2	3.8 E-3	---	5.0 E-2	1.0 E-3	1.2 E+1	4.2 E-2	8.8 E-3

process worker being exposed to a higher average concentration by virtue of being near the tanks a small portion of the day) is in the range of the TLV, at 0.05 mg/m<sup>3</sup> and the REL, at 0.001 mg/m<sup>3</sup>. These concentrations also greatly exceed the non-cancer RfC of 8x10<sup>-6</sup> mg/m<sup>3</sup> for hexavalent chromium. The cancer risk for both workers is in the range of 10<sup>-2</sup>. As discussed earlier for the demonstration of the TRI facilities, EPA typically considers a lifetime cancer risk of 10<sup>-4</sup> to be of concern and warrant some further activity.

### 3. Comments on the Demonstrations

As seen, there is conservatism built into MFFRST that users must be aware of. In these examples, the following features demonstrate this conservatism:

1. “Chromium compounds”, as reported to TRI, are assumed to be fully hexavalent chromium when released, and are assumed to remain in this form from stack to receptor. Lorber, et al. (2000) reviewed the literature to find out what proportion of “total chromium” in the air (both in the workplace and in the ambient environment) was in the form of hexavalent chromium. They found measurements ranging from less than 10% to 100%. One study, in particular, measured total and hexavalent chromium upwind and downwind of a chrome plating facility. “Downwind” measurements were taken by turning on the air monitoring equipment when the wind was known to be blowing from the stack to the air monitoring device. Downwind at 0.3 km, the percent of hexavalent to total chromium for four measurements were 27, 35, 93, and 100%. The two highest hexavalent chromium measurements at 110 and 316 ng/m<sup>3</sup> were also the ones with percentages above 90%. In other measurements not downwind, the hexavalent to total chromium ratios ranged from <10 to 67% with a mean of 25% (n=10).
2. The RfC already has conservatism built into it with the use of uncertainty and safety factors. The unit risk factor used to calculate the cancer risk is also developed conservatively at EPA. This cancer risk is

specifically defined as the upper bound cancer risk, meaning that the true risk is not likely to be higher and could very well be lower, given an average lifetime exposure defined within the specified scenario.

3. The air concentration predictions are for a scant 100 meters from the facility. SCREEN3 will predict an annual average concentration at this location assuming this location to be in the predominant downwind direction from the facility. In other words, if the exposure location were in a predominantly upwind direction in relation to the facility, then the predicted concentration would be much less. As well, no transformation or other loss of emitted constituents are assumed in the SCREEN3 simulations.

4. Residential receptors are assumed to be exposed for 30 years and 350 days/yr, and workers similarly have a long worklife of 30 to 40 years. These exposure times influence the prediction of a lifetime cancer risk. Lower cancer risks would be predicted for individuals assumed to live for a shorter amount of time near the facility, or to work a shorter amount of time within the facility.

The demonstration above focused on the decorative chromium line and showed predicted air concentrations of hexavalent chromium that are comparable to the occupational endpoints of the PEL and TLV, that are 3 orders of magnitude higher than the inhalation RfC for hexavalent chromium, and that can result in lifetime cancer risks on the order of  $10^{-2}$ . This cancer risk estimate is two orders of magnitude higher than what EPA typically considers to be of concern. This would imply in a real situation that further modeling and/or air monitoring would be needed to more accurately estimate these risks.

What is also highlighted here is the difference in the emissions predicted to occur out of stacks for the generic plating lines and the emissions reported to TRI by facility owners. The demonstration TRI facilities were reporting 10 and 500 lbs/yr of chromium emissions, while the generic plating line was predicting an emission of 0.01 lbs/yr out of the stack. This discrepancy in TRI and predicted emissions was reported on during the AESF/EPA conference in 2000 (Schwartz and Lorber, 2000), and several possible explanations were offered for this difference. One of the key differences is that the TRI record used in MFFRST is for "total" air emissions, which include both stack and fugitive emissions, and that these total emissions are modeled as though they came out of the stack. Schwartz and Lorber (2000) reviewed TRI data for both fugitive and stack emissions in the electroplating industry, and observed that for metals, metal compounds, and acid emissions (e.g., sulfuric acid), respondents have reported that approximately one third to two thirds of these total emissions are, in fact, fugitive rather than stack. This is one reason why a comparison of emissions from the generic line out of the stack to the TRI record is not a direct comparison. Still, a comparison of TRI stack emissions with MFFRST-predicted stack emissions from the generic lines would still show a 3 to 4 order of magnitude difference. During this year's conference, Schwartz reports on an important new validation of the procedures to predict stack emissions in MFFRST (Schwartz and Lorber, 2001). He shows a good match between model predictions and measurements of controlled and uncontrolled chromium emissions. Overall, the model underpredicted emissions by about a factor of 6 (most tests showed an underprediction, but there were some overpredictions in MFFRST). Using the annual predicted emissions of 0.01 lbs/yr as just reported, this suggests that real-world annual emissions of chromium may be in the range of 0.1 lb/yr, which is still significantly lower than total (or stack alone) air emissions reported by TRI.

## **Update on MFFRST**

As of the drafting of this manuscript, the MFFRST model code is complete, as is the technical support document. The document chapters include: 1) Introduction, 2) Identification of Major Contaminants and Generation of Source Release Estimates, 3) Modeling the Fate of Contaminants From Source to Receptor, 4) Development of Exposure Scenarios and Risk Estimation, 5) Model Testing and Evaluation, and 6) Monitoring for Key Contaminants. There is an Appendix providing a User's Guide to MFFRST. It describes how to install and run MFFRST. It also describes the data records and data record files which accompany MFFRST. Users can edit or even replace those files, to bring them more up to date or to better suit their needs. For example, a user can update the TRI data base with new TRI records or with any TRI-like record. When MFFRST is then run, it uses the updated TRI data base file.

EPA will pursue finalization of this document and model through normal clearance procedures. At that time,

both the model and the accompanying technical support document will be made available through postings on the internet at appropriate web sites.

As of this writing, work is just beginning on the inclusion of other waste streams into MFFRST. These include liquid (wastewater) and solid (sludge) waste streams. Procedures to evaluate the potential impacts of these waste streams, and the incorporation of those procedures, will occur during 2001. There is no timetable on these planned additions, but it is likely that we will report on their progress during the 2002 AESF/EPA conference.

## **References**

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