University of New Haven

School of Public Safety
and Professional Studies

300 Orange Avenue
West Haven, Connecticut 06516
203-932-7000

May 13, 1996

Diane Manning
NIOSH
Education and Information Division
MS C34
4676 Columbia Parkway
Cincinnati, OH 45116-1998

Re: Review of NIOSH Criteria Document on Metalworking Fluids

Dear Ms. Manning:

Thank you for the opportunity to review a draft of the NIOSH **Criteria For A Recommended Standard: Occupational Exposures to Metalworking Fluids**. The document is quite thorough and obviously was the result of a significant effort by personnel at NIOSH. Like many other Criteria Documents I have read, it contains a wealth of knowledge for the practicing health professional.

I have provided comments in three ways. A general critique of the document is provided below. I have also included in a second section specific comments relating to identified areas of the criteria document. Finally, I have provided some comments written directly on the manuscript that tend to be more editorial in nature. Although most of my comments are critical in nature, I have at times tried to identify what I thought were very positive aspects of the document. The lack of more positive comments does not reflect my opinion of the document, but rather the nature of a critical review.

General Comments

General Organization- I would have preferred a more traditional organization for this document. The background contained in the first 10-12 pages is appropriate. This could then be followed by the NIOSH REL. I would then follow this with a toxicological summary of what is known about the different types of fluids and additives from animal testing, then effects on humans (first lung function effects followed by, asthma, dermatitis, diseases of the lung parenchyma and finally cancer studies). I would then discuss sampling and analytical methods, medical monitoring, and lastly a summary of the entire occupational safety and health program needed. In summary the document would look as:

I. Background on metalworking fluid operations including numbers of workers exposed.

II. NIOSH REL including a summary of why a standard is needed and comparison to existing health standards.

III. Effects on Animals
- A. Effects of four types of fluids
- B. Effects of fluid additives
- C. Effects of biocides

IV. Effects on Humans
- A. Lung function changes
- B. Asthma
- C. Dermatitis
- D. Lung parenchyma
- E. Cancer

V. Methods for Monitoring MWF
- A. Airborne methods
- B. Fluid methods for bacteria, fungi and maybe biocides

VI. Medical Monitoring of Workers

VII. Description of a Comprehensive Health and Safety Program
- A. Training
- B. Use of Personal Protective Equipment
- C. Engineering Controls

Development of the REL- I have trouble understanding the recommendations for a 0.5 mg/m^3 for metalworking fluid (MWF). None of the epidemiological studies cited found a no-effect level (NOEL). Several of these studies were at levels well below 0.5 mg/m^3. The document provides references that recent studies continue to show workers have health complaints while many workplaces have levels below 0.5 mg/m^3. It does not seem to be worth the effort to develop an REL unless there is some evidence that implementation of this standard will protect a sufficient number of workers. Although discussed later in my comments, most irritants have short-term or ceiling exposure limits associated with them. The data discussed regarding pulmonary function decrement describes a respiratory irritant. If this is the case, what rationale is there for a TWA REL except that it may be either easier to collect data or conventional. There certainly are real-time instruments that can collect these data. What may be more appropriate is to develop a guidance document that will assist employers and employees without recommending a specific occupational exposure limit.

Toxicological Data and Endpoints- There is a lack of discussion of acute and chronic animal studies available on the basic fluids, additives, and final fluids. While some of these data may not be available (but should be developed), there is clearly more data than what is discussed in this document. My experience with just some of the biocides indicates that these are approved by EPA under FIFRA and there is extensive animal data available. The discussion and development of these data are critical in judging the reliability of the epidemiological studies presented. This is especially true for the discussion on cancers where the variety of fluids and additives make interpretation of the existing studies difficult. This is also an important area when developing the next generation of fluid formulations. Clearly animal data have been useful in determining to reduce the PAH content of mineral oils used in MWF and the prohibition of nitrites in fluids.

Monitoring for Metalworking Fluid- It is unclear that if the REL were implemented how one would monitor for MWF to determine compliance. The following questions need to be addressed:

- What are the contributions from vaporous components of MWF, and is a two stage sampling device necessary?

- For all but straight fluids, do you measure water and consider it as part of the REL? The water component may be important if exposures to biological contaminants are significant.

- If you chose to measure water, how quickly must you perform analyses to avoid losing samples on filters from evaporation?

- At 5 mg/m^3, ambient aerosol levels may not be that important. At 0.5 mg/m^3 the contribution and significance of other particulate matter in the air is going to be important.

- The current standards being developed throughout the world will address inhalable, thoracic and respirable fractions. Does it make sense to have a total dust standard when the international community is moving to one of the above types of monitoring methods and applicable standards?

- What is the importance of short-term exposures to MWF? Many irritants are regulated based on short-term and not TWA measurements. If this is the case, methods discussed in the document will not adequately address exposure.

In summary, I cannot think of an occupational exposure limit as low as what has been proposed and using gravimetric analysis as anything but a screening tool.

Specific Comments

1: Page 5, Table 2-1: Re-label “insoluble oils” as “straight oils”. Add water as a component of MWF.

2. Page 14, Table 3-2: The heading under description appears to be mistitled. It appears that the text is referring to industry codes but job titles are described. The miscellaneous category covers a lot of workers and then you have all occupations. Perhaps this is the best you can do with the data available, but this is not a very useful or informative table. It would be better to list the number of workers exposed by industry and not bother with job titles. Job titles would be useful within a specific OCC code to differentiate jobs with the most exposure.

3. Page 15, Table 3-3: Some discussion is probably necessary in the text to examine differences in how samples have been collected and analyzed over the time periods noted. A significant, and

sometimes majority, number of samples fall in the > 1 mg/m^3 category. Is there a way of distinguishing >1 mg/m^3 from >5 mg/m^3 , the OSHA PEL for this substance? This would identify those operations that are currently not in compliance with the OSHA PEL.

4. Page 16, second paragraph: Normally industrially hygiene air sampling data are log-normally distributed, and we refer to geometric means values. It is likely that there is normal distribution of these data among the plants, so maybe what you should be referring to is the arithmetic mean of the various geometric mean values. It would be interesting from the OSHA IMIS data to examine worker exposures among large and small facilities. It is possible that OSHA has conducted a disproportionate number of surveys in larger facilities that have union representation, and this summary may not adequately describe exposures for the more numerous smaller facilities.

5. Page 21, first paragraph: Mention is made of Table 4.1-1 but this does not appear for 30 more pages. In fact, Table 4-1-14 appears before this table. Although Table 4-1-1 is large and cumbersome, it should appear either when first noted or in the correct sequence with all other tables at the end of the chapter.

6. Page 22, second sentence: Is it necessary to describe the significance of a risk estimate <1.00 when the upper 95% confidence interval is < 1.00? This is describing a protective effect for which there is no plausible explanation. Unless there is some medical rationale to examine these data because of their protective effect, it would not appear worthy of mention.

7. Page 46, second paragraph: I have trouble comparing air sampling data collected as early as 1949 with data collected in late 1988. Not only are monitoring methods greatly different (including filter media available), but these data include those from both straight and soluble oils.

8. Page 47, top of the page: It is not clear what exposures are being reduced (I think you mean total particulates only). It is possible that with the advent of recirculating air cleaners the vaporous components of MWF are increasing. The addition of new biocides and additives may also be increasing the exposures of employees to related materials, even if the total particulates are declining.

9. Page 48, middle paragraph: The statement is made that lack of consistency from study to study may be due to differences in classes of metalworking fluids and formulations and should not weigh heavily in evaluating carcinogenicity of these substances. This can also be interpreted to mean that when studies demonstrate a carcinogenic end result, it may be due to previous formulations that contained high concentrations of PAHs or nitrosamines and may not reflect the effects of current formulations.

10. Page 49, lines 2-5: I agree with the statement that there is no evidence that MWF exposure is responsible for cancer (this does not mean it is free from implication).

11. Page 50: Rephrase the statement that "Reductions in the exposure concentrations likely have reduced the risk." I know of no reliable model that does not show some dose-response relationship.

The only way that reductions did not reduce risk is if the exposures were not responsible for any excess cancers seen in the first place (either no relationship or below threshold for causing cancer).

12. Page 76, first full paragraph: The text describes that working with MWF was responsible for 13% of the 725 cases of asthma reported in the Michigan SENSOR program. It is not clear the significance of this statement. How much machining and use of MWF occurs in Michigan. I presume that it is a significant amount, given the presence of the major automotive manufacturers (the values seem out of context).

13: Page 78, line 10-12: Add that it is also possible that there was no effect due to exposure to metalworking fluid. The NIOSH Criteria Document should be objective as possible. If a study fails to find a cause and effect clearly one possible explanation is that there is no relationship.

14. Page 80, first paragraph: Although indicated elsewhere, please state the number of workers examined in the Kriebel study.

Also in this paragraph, please better describe the seven-hole cassette inlet face. Is this a prototype for sampling for inhalable fraction or is it commercially available. Only a couple of these devices have been validated for inhalable testing. I would also make a note that total inhalable fraction of particulates of 0.22 mg/m^3 would suggest a very clean environment (from an aerosol perspective).

15. Page 81, second sentence: Is some reference to numbers of years of exposure required?

16. Page 96-98, Table 4-2: One general observation from this table is that risk of respiratory symptoms is not related to the intensity of exposure. This is not completely fair, as there were a number of studies reported in the early 1980's that probably looked at different types of fluids than those in the 1990's. The Greaves study indicates effects as per mg/m^3, but the others do not show a qualitative dose-response relationship (note: the implication is not that the effects are not real or related to MWF, but these effects may not be related to total aerosol concentration).

17: Page 105 end of first paragraph: Last sentence makes an important point regarding the fact that workers in many facilities being examined have been exposed to a variety of oil from previous formulations. This can confuse interpretation of studies by reducing statistical significance of disease or attributing such disease to the wrong formulation. This issue goes beyond simply the type of oil being used and includes additives and even bacteria and fungi (it may be that biological agents were not controlled as well in earlier years or perhaps they were better controlled).

18: Page 112, second line from the bottom: when you refer to unexposed assembly workers, qualify the exposure to state that the median exposure to ambient aerosols was 0.14 mg/m^3, unless you do mean that exposure was to MWF.

19: Page 113, line 10: I have trouble referring to 0.16-0.47 mg/m^3 as medium exposure and > 0.47 mg/m^3 as high exposure. Although these are relative terms, I would consider using "low" and "medium" as exposure modifiers.

20. Section 4.2.5.: I thought this was well written and covered the issues well.

21. Page, 132, Table 5-1: Please note that the following biocides are not formaldehyde releasing and should be moved to Table 5-2:

Bioban P-1487 (no evidence that it releases formaldehyde upon use)
Sodium Omadine
Proxel CRL
Kathon 886
Dowicide-1

22. Page 133 second paragraph: Please modify first sentence to: "Studies suggest that exposure to some biocides can cause....."

23. Bottom of Page 133-top of Page 134: Please change "formaldehyde aerosols" to "formaldehyde". This study only measured formaldehyde vapors. Please modify the discussion to add that "This study identified areas using MWF with levels above 0.1 ppm of formaldehyde where no known source of formaldehyde was present. This study demonstrated formaldehyde exposures were consistently below the OSHA Action Limit of 0.5 ppm".

24. Page 135, Section 5.3: When discussing potential sensory or pulmonary irritants you are missing an important study. See *Prediction of an Occupational Exposure Limit for a Mixture on the Basis of Its Components: Application to Metalworking Fluids* by Krystofiak and Schaper published in the *AIHA Journal 57:239-244 (1996).*

25. Page 142, second paragraph: Can you discuss the significance of finding NDELA in metalworking fluid at levels of 0.1-0.3 ppm. This is orders of magnitude below that which OSHA would require labeling for as a suspect carcinogen. What are the exposure consequences for skin and inhalation at this level? (I assume either very small or of no significance). I believe that free formaldehyde (another carcinogen) from fluids using biocides with formaldehyde condensates would be higher than this level in fluids.

26: Page 154, Table 7-1: add "severely refined" to the oil mist category and add OSHA PEL of 3 ppm (8 mg/m^3) to ethanolamine category.

27: Page 155, Table 7-1 cont'd: Indicate 0.001 mg/m^3 to NIOSH REL for chromium compounds as insoluble (VI) and add 0.1 mg/m^3 to OSHA limit for chromium as insoluble (VI).

28. Page 157, Table 8.1: Is it important to distinguish these methods based on different classes and types of fluids?

29. Page 158, Section 8.2: This deals with gravimetric analysis errors in a very rigid manner. I would consider the following issues important in identifying perhaps larger sources of error:

- measurement of the actual MWF and additives (as opposed to total particulates)
- measurement of water
- measurement of non-MWF/additive aerosols (dust, metals, etc)

Very briefly, water and fluids may evaporative from collection filters resulting in the loss of sample and underestimating the concentration of MWF. The collection of non-MWF aerosols can result in erroneously attributing exposures to MWF.

The same issue applies to discussion in first paragraph at top of page 162.

30. Page 160 text below Table 9-1: I appreciate the difficulty of the authors in writing this sentence but there is an inconsistency. One cannot show the data from Table 9-1, discuss the results of the recent epidemiological studies that all demonstrate exposures below 0.5 mg/m^3 and indicate that it is impossible to judge the feasibility of achieving the REL. I think that a more appropriate statement(s) would be that for some older operations, smaller establishments, or for some specific metalworking operations it may be difficult to achieve the REL, and insufficient data is available for determining cost and feasibility.

31. Page 186, second paragraph: The text states that an occupational exposure limit of 0.2 mg/m^3 might be required to protect against non-malignant risk and cites Kriebel's study. The problem is that this is not a NOEL based on this study and the statement is unsupported.

32. Page 194, top of page: Certainly an important missing component of an occupational safety and health program will be proper fluid management and control of bacteria and fungi.

33. Page 200, lines 3-6: I am not certain why there are recommendations to wear PPE during the addition of bulk biocides. This issue is covered by EPA and FIFRA. I would think that to follow the manufacturer's instructions is appropriate. Some biocides are corrosive and require special care, others may require no more than normal protection (e.g. safety glasses).

34. Page 201, top of page: The entire issue of microbial control is poorly described. If it is not the intent of NIOSH to expand this, then some reference to manufacturers' literature or some basic reference is needed. It may be desirable to state that someone familiar with fluid management including control of microorganisms should have responsibility for the fluid system.

35. Page 206, line 7: I take exception that the best guide is the TWA REL as it may be that an STEL or peak exposure standard is the best guide.

36. Page 208, table 10-5-2-1: NIOSH no longer uses the term dust, mist fume and mist for identifying grades of filter media. Please use current terminology (N,R,P designations for 99.97%,

99% and 95% filter efficiency). For exposures above 10 x REL why can't one use a full face negative pressure device as stated in the NIOSH RDL?

37. Page 211, first paragraph: change medical monitoring requirements from where "one or more workers have developed respiratory effects related to MWF exposure" to "where there has been one or more OSHA recordable respiratory illness attributed to MWF". This is less subjective and easier to administrate.

Editorial Related Comments

Please see text for comments written directly on the manuscript. These can be found on pages:

22, 56,128, 129, 134, 150, 159, 166, 168

Again, thank you for the opportunity to review this document. If you have any questions regarding my comments, you may reach me at 203-932-7238, 203-931-5054 (fax) or email at: aihaj@charger.newhaven.edu.

Sincerely,

Howard J. Cohen, Ph.D., CIH

significant if the lower bound of the 95% confidence interval for the risk estimate was $\geq$ 1.00 or if the two-sided p-value was $\leq$ 0.05 (conversely, a risk estimate < 1.00 is considered statistically significant if the upper bound of the 95% confidence interval is <1.00, or the p-value is $\leq$ 0.05. In tabulating the number of studies with significantly positive findings for each site, a study was counted as statistically significant if the risk estimate overall, or in a relevant major subgroup, was statistically significant. Although statistical significance is not the sole criteria of importance in interpreting the results of a single study, or summarizing data from multiple studies, it is used as a summary measure in this review because it is applicable

to all studies and its meaning is widely understood. Confidence intervals, which are preferable to p values in interpreting epidemiologic data, are provided in this review for studies where they were reported by the authors.

Tables 2-13 summarize the data generated to examine the association between MWF exposure and risk of cancer at specific organ sites. In an effort to keep the tables to a reasonable size, not all of the risk estimates reported by these studies are included in our tables. From the Tolbert study we provide the risk among those ever exposed to each of the specific classes of MWFs, and from the remaining studies we provide the risk for all workers with potential MWF exposure, and when available, the risk among those workers with the highest duration of employment.

Table 4.1-5, Results for Laryngeal Cancer from Epidemiologic Studies of MWF-exposed Populations

Author	Location	Type of Study/ Analysis	# with CA or # Exposed Cases	Risk Estimate	95% CI (or p-value)	Study Population/Cancer Site
Cohort Studies						
Tolbert et al., 1992	Michigan	SMR	23	1.98	1.28,2.98	ever straight oil exposure, white
			30	1.41	0.95,2.01	ever soluble oil exposure, white
			8	1.57	0.68,3.09	ever synthetic oil exposure, white
			1	0.50	0.01,2.78	ever straight oil exposure, black
			64	0.91	0.70,1.17	ever soluble oil exposure, black
Eisen et al., 1992	Michigan	SMR	2	0.77	0.09,2.79	white autoworkers, Plant III
Eisen et al., 1994	Michigan	nested case/control	28	2.23	1.25,3.98	highest exposure to MWFs
Proportionate Mortality Studies						
Vena et al., 1985	New York	PMR	3	1.81	NS	based on US mortality, white
Mallin et al., 1986	Illinois	PMR	7	1.79	NS	white
Population-Based Studies						
Zagraniski et al., 1986	Connecticut	case/control	22	2.5	1.2,5.2	ever worked as a machinist
			17	2.1	1.0,4.7	ever worked as a metal grinder
Wortley et al., 1992	Washington State	case/control	NA	1.8	0.5,6.2	ever employed as grinding, abrading, or buffing operator
			19	1.0	0.5,1.9	ever employed in precision metal working
Haguenoer et al., 1990	France	case/control	7	1.8	NS	employed in metal work or as mechanic for at least 15 years
Brown et al., 1988	Texas	case/control	5	0.53	0.18,1.58	ever machinists
Ahrens et al., 1991	Germany	case/control	NA	2.2	0.9,5.3	ever mineral oil exposure

ON PG 32 WRITTEN AS 1.8

The NTP stated that there was "equivocal evidence" of carcinogenic activity in the TEA treated male rats and concluded that the lack of both a clear dose-response and an increase in the total number of proliferative renal lesions in dosed male rats raises doubt that this result could have been attributed to TEA administration. Since there was no significant terminal increase in tumors for female rats in the treatment or control groups, the NTP concluded that there was "no evidence" of carcinogenic activity induced in these TEA treated females [NTP 1994].

The NTP [1994] also reported the experimental results of a significant increase (P=0.03) in hepatocellular adenomas in high dose male mice when compared to the concurrent controls. No differences in incidence of hepatocellular adenomas were observed for either the of the two lower dose males. When the terminal incidences for hepatocellular adenomas and carcinomas, and hepatoblastomas were combined for the high dose males, they also became statistically significant (P=0.018). However, these male mice were found to be infected with *Heliobacter hepaticus*, the presence of which has been associated with increased incidences of hepatocellular neoplasms in male mice and this may be a confounding factor in the interpretation of carcinogenicity studies [Ward et al.1994a]. This infection in male mice was a significant factor in the N.T.P.'s final determination of "equivocal evidence" of carcinogenic activity in treated male mice based on the possibility that the increased numbers of hepatocellular adenomas induced by the *Heliobacter* infection.

Elevated hepatoblastoma rates did not occur in the treated female groups. However, hepatocellular carcinomas were significantly increased in the 300 mg/kg treated female group (*P*=0.02), while only hepatocellular adenomas were significantly increased in the 1,000 mg/kg treated female group (*P*<0.001). When these hepatocellular adenomas and carcinomas were combined within each female treatment group, they were only statistically significant for the 1,000 mg/kg dose (*P*<0.001) . Because the carcinoma rate among the 300 mg/kg treated female mice was well below the NTP historical control, and there was no consistent dose-related increase in hepatocellular carcinomas for the other treatment groups, NTP decided that the elevated carcinoma rate observed in this experiment was not related to TEA exposures. NTP also pointed out that Ward et al. [1994b] suggested that female mice have a low susceptibility to *Heliobacter* infection when compared to males, suggesting that the increased incidence of hepatocellular adenomas was related to the TEA treatment. NTP concluded that there was "some evidence" of an elevated adenoma rate in the treated female mice.

Hoshino and Tanooka [1978] reported a significantly increased lymphoma incidence (*P*<0.05) for combined groups of ICR-JCL female mice. However, there was a low lymphoma incidence rate compared to historical control, and the increased lymphoma rates in treated mice which were reported by Hoshino and Tanooka may not have been induced by chronic ingestion of TEA.

containing Triazine may exceeding the OSHA Formaldehyde Standard of 0.1 ppm threshold for labeling and training [Cohen 1995, 29 CFR 1910.1048].

In addition there is some concern that nitrated biocides such as bromopol (2-bromo-2-nitro-1,3-propanediol), 2-methyl-2-nitro-1,3-propanediol, and 5-methyl-5-nitro-1,3-dioxane which have been shown to release nitrite, can act as nitrosating agents in MWFs. Bioban P-1487, which is composed of 70% 4-(2-nitrobutyl) morpholine and 30% 4,4'-(2-ethyl-2-nitrotrimethylene) dimorpholine, can dissociate to form nitrite ions, which may react with alkanolamines amines, such as the mono-, di-, and triethanolamines, to form nitrosamines. Bioban P-1487 added to MWF concentrate can directly form NMOR (an animal carcinogen [IARC 1978b]), which can increase in concentration over time [Mackerer 1989]. It is unclear whether this could result in any measurable worker exposure.

5.4 Chlorinated Paraffins

Chlorinated paraffins are used as extreme-pressure additives that are activated by the heat generated during metalworking to form a film between the tool and work to prevent destructive welding, excessive metal transfer and surface breakdown [Nachtman and Kalpakjian, 1985]. Long-chain and short-chain chlorinated paraffins (C_{23}, 43% chlorine and C_{12}, 60% chlorine) were selected by the National Cancer Institute (NCI) for toxicity and carcinogenicity evaluation. NTP

7. Current Occupational Recommendations and Standards

In 1976, NIOSH published *Current Intelligence Bulletin 15: Nitrosamines In Cutting Fluids,* which identified the presence of potentially carcinogenic PAHs and nitrosamines in MWFs (**6. Potentially Hazardous Contaminants**), and recommended industrial hygiene practices to minimize dermal and respiratory exposure [NIOSH 1976]. OSHA has classified NDMA as a cancer-suspect agent [29 FR 1910.1016]; it is regulated as an occupational carcinogen. Exposure of workers to NDMA is controlled through the required use of engineering controls, work practices, and personal protective equipment, including respirators [20 CFR 1910.1003-1910.1016]. NIOSH has identified NDMA as a potential occupational carcinogen and recommends that occupational exposure to NDMA be limited to the lowest feasible concentration [NIOSH 1973]. The American Conference of Governmental Industrial Hygienists (The ACGIH) has designated NDMA with an A2 classification of "Suspected Human Carcinogen" [ACGIH 1993b].

Particularly in the past, petroleum-based mineral oils used in insoluble, soluble, and semisynthetic MWFs were be derived by limited refining by vacuum distillation or acid treatment, or severely- or mildly-treated by solvent-refinement or hydrotreatment [IARC 1987a]. As noted previously (5.2 Mineral Oil), the Occupational Safety and Health Administration (OSHA) Hazard Communication Standard (HCS) [FR 1985] requires that employers report on material safety also present in total dust sampling. Baron et al. [1995] have demonstrated a significant bias depending on the orientation of the sampler to the wind. Preliminary reports of ongoing work at Health Safety Executive (London) indicate that sampling efficiencies of most conventionally used aerosol samplers to be biased (especially for larger diameter particles) and very dependent upon wind speed [Kenny, personal communication]. Further research will be required before a more precise estimate of aerosol method bias can be obtained.

8.3.2 Estimation of Total Method Precision

For a gravimetric technique the LOQ is 130μg per filter [Shulman and Glaser 1995]. This estimated LOQ is based solely on that mass at which the gravimetric error becomes 10%. If the analytical finish involves further extraction of the sample, the imprecision is likely to increase. Several analytical scenarios are considered where the sample is extracted but different extraction efficiencies are obtained. It is possible to estimate the maximum imprecision associated with sampling and analysis at the LOQ if appropriate estimates of all error sources are known. Potential sources of error for each of these contingencies are considered in **Table 8-3, Sources of Error (Relative Standard Deviation, RSD) for Various MWF Sampling and Analytical Techniques, for Samples Collected at or Near the LOQ.** While the magnitudes of these sources of imprecision are generally unknown, assumptions must be made to allow for their estimation. Generally, the pump precision is assumed to be 0.05. Intersampler variability may be

This **Basis for a Recommended Exposure Limit (REL)** summarizes the studies used to develop the REL and other recommendations needed in a comprehensive occupational safety and health program. These studies provide the best available evidence of the association between adverse respiratory health effects and occupational exposure to MWFs.

9.1.1 Industry Trends

Major changes were introduced into the U.S. machine tool industry over the last several decades. The overall consumption of MWFs and specifically the use of synthetic MWFs increased as tool and cut speeds increased. Advances in automation enabled the machines to be partially enclosed which facilitated the application and use of local exhaust ventilation. During the 1970s and 1980s, many U.S. plants installed recirculating air cleaners, improved the recirculating air filtration systems, and renovated the factories. The improvements were prompted in some part by the ACGIH threshold limit value (TLV) of 5 mg/m^3 for mineral oil mist established in the 1960s, and its promulgation in 1970 by the Occupational Safety and Health Administration (OSHA) as a permissible exposure limit (PEL).

The study by Hallock et al. [1994] describes the effectiveness these changes had in the automotive industry on reducing exposures to airborne MWFs. Airborne MWF concentrations were found to have significantly declined over a 30-year period (1958-1987) with an arithmetic

These data indicate that the arithmetic mean personal exposure concentrations (total particulate) were 1.23 mg/m^3 (n=21 plants) in the 1970s, 0.57 mg/m^3 in the 1980s (n=15 plants), and increase to 1.0 mg/m^3 in the 1990's based on only two plants . The overall mean concentration for 38 plant-based HHEs was 0.96 mg/m^3.

This decline in airborne exposures has also been reported in the Integrated Management Information System (IMIS) of OSHA which compiles the environmental samples from OSHA inspectors. From 1979 to 1995 (**Table 9-1, OSHA-Integrated Management Information System (IMIS). Number of oil mist (MINERAL) Samples and % by year ranges** (1979-February 1995), OSHA has collected mineral oil mist exposure data for IMIS, which represent a substantial cross-section of industry. These exposure data demonstrate a steady decline in exposure concentrations from 1980 to the present. The arithmetic mean concentration for all samples collected during this time period was 0.92 mg/m^3 (total particulate); for the period 1989 to 1994, the arithmetic mean was 0.49 mg/m^3. The increasing percentage of samples with airborne concentrations below 0.5 mg/m^3 over time suggests that improvements in engineering controls and work practices have occurred. Airborne concentrations, prior to 1980, have declined from 37% of all samples with airborne concentrations less than 0.5 mg/m^3, to 42% of all samples at less than 0.5 mg/m^3 from 1980 to 1984, and to 73% after 1989.