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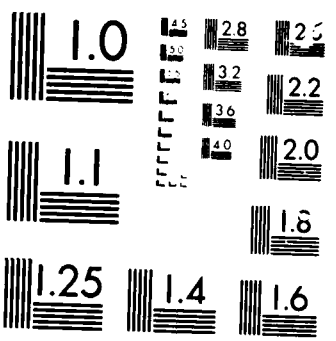
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USAFOEHL REPORT
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A GUIDE TO THE ESTIMATION OF THE HAZARD PRESENTED BY CHEMICALS IN HUMAN MILK

NOVEMBER 1985

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USAF Occupational and Environmental Health Laboratory
Aerospace Medical Division (AFSC)
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USAF OCCUPATIONAL AND ENVIRONMENTAL

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A Guide to the Estimation of the Hazard Presented by Chemicals in Human Milk

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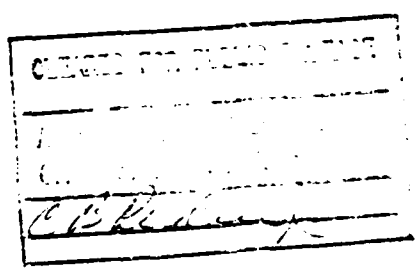
This report is written in response to requests from the field for assistance in determining the risk presented by potential contamination of breast milk by the industrial environment. It includes a method for estimating the likelihood of contamination of breast milk by a given chemical and delineates a method for sampling breast milk if the estimating procedure indicates that a significant risk may exist.



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I. INTRODUCTION

A. Purpose

This guide was prepared at the request of HQ USAF/SGPA. It provides guidance to assist in determining if a particular work environment is safe for breast feeding mothers. The specific concern is that chemicals in the work environment may be transmitted via breast milk and cause damage to the breast feeding child.

B. Problem

The magnitude of this problem for the Air Force has never been addressed. Recent studies have shown that if mothers returned to work before the sixteenth week post partum and are employed full time, the likelihood of weaning before the sixth month increases substantially. Air Force women fit the category of early return to full time employment. The pregnancy rate among active duty females is 5 to 10% and approximately 50% of women choose to breast feed. Given these figures the number breast feeding at any one time would be as follows:

67,034 active duty females x 10% pregnancies = 6703 pregnancies

Assuming 50% elect to breast feed = 3350 breast feeding mothers.

The number of civilian employees is 204,186. The number of women in that force is unavailable but certainly at least 50% are women. The average age is 43 as opposed to an average age of 30 for active duty personnel, therefore the pregnancy rate should be lower and probably does not exceed 5%. Following the same parameters as used with active duty women, the average number of civilian workers breast feeding their infants is approximately 5,100. Very few of these women work in hazardous areas, the majority being in clerical and support positions. If half of all women in the Air Force and in civilian jobs with the Air Force work in potentially hazardous jobs, the total number of potentially exposed women breast feeding their infants is approximately 4,200. This is 0.52% out of a total work force of 806,286. Potentially exposed mothers who choose to breast feed their infants would constitute about 2.5% of the female workforce. In terms of overall magnitude this appears to be a minor problem. Nevertheless the question of whether a sufficient dose of chemical will be received by the nursing infant to produce a toxic effect is of legitimate concern in those limited situations where it arises. It must be remembered that as of this writing no problem has been demonstrated with maternal exposures at or below the TLV.

C. Scope

The scope of this report is limited in terms of the actual substances covered in the tables. As time and resources permit, others may be added. The primary objective is to offer a method of determination which can be applied to any substance for which the parameters are known or can be derived.

This report provides a logical decision-making process to determine the risk of exposure from breast feeding.

II. DISCUSSION

A. LACTATIONAL TRANSFER OF SUBSTANCES:

Passive transfer accounts for many of the beneficial components in human milk. Passive transfer also accounts for the majority of potentially detrimental substances found in human milk. It is a process involving diffusion of a compound from the blood, within capillaries surrounding the secretory mechanism of the mammary gland, into the milk. Since it relies on relative solubility in these compartments, the extent of passive transfer of a substance is determined by its chemical properties and by the chemical composition of blood and milk. The efficiency of the process is often depicted in the milk-plasma (MP) ratio, which indicates the relative concentration of a chemical in maternal milk and blood. Six agent-specific factors and one maternal factor effect the milk-plasma ratio. Agent-specific factors include: ionization constant (pka), protein binding, molecular weight, chemical/physical interaction, elimination/metabolism, and lipid solubility. The maternal factor is blood flow.

Ionization Constant (pKa):

Studies of the penetration of chemical from the systemic circulation into milk indicate that the mammary gland epithelium functions like a lipid membrane which separates blood of pH 7.4 from milk which has a slightly lower pH. Foreign compounds move passively via diffusion from blood into milk across this lipid membrane barrier. Thus, only the lipid soluble, nonionized moiety of an organic electrolyte in the water phase of blood diffuses into milk. The pKa of the organic acid or base can thus be used as a predictor of relative partitioning behavior between blood and milk. Weak acids tend to give milk-plasma ratios of less than one and weak bases tend to give milk-plasma ratios greater than one.

Protein Binding:

Another parameter which may be used to predict blood-milk partitioning is the extent of protein binding. In the case of blood, this protein is albumin. However, milk also contains the protein, casein, which may also bind a chemical. If other factors are equal, a highly plasma-protein bound agent would tend to partition into milk to a lesser extent than would a slightly protein bound chemical. Compounds bound to erythrocytes will have low milk-plasma ratios.

Chemical/Physical Interaction:

Another factor is the potential for interaction between a chemical and milk constituents. Agents which are chemically similar to calcium, such as lead; or are transported like calcium, such as cadmium, may be actively excreted to a significant extent via the milk.

Molecular Weight:

Agents with a low molecular weight (<200 MW) tend to partition more effectively into milk than agents with high molecular weights (>200 MW).

Elimination/Metabolism:

Metabolism usually produces a less lipid soluble, less toxic compound. Chemicals that are rapidly metabolized and/or eliminated from the blood such as formaldehyde have less time to partition extensively into milk and don't reach significant levels. Agents which are very slowly eliminated from the body; such as lead, mercury, DDT or PCBs, are available for transmission into milk during lactation.

Lipid Solubility:

The last, and most important agent specific factor in predicting blood-milk partitioning is lipid solubility. As stated previously the mammary gland epithelium functions like a lipid membrane, readily allowing the passage of nonionized, lipid soluble compounds. Milk contains a suspension of 3-5% lipids, significantly higher than that found in blood. Together these two physiologic factors effectively increase the amount of a lipid soluble material present in milk. Thus, highly lipid soluble chemicals such as PCBs or DDT may be found at higher concentrations in milk than in maternal blood. In addition, agents which are highly soluble and slowly eliminated from the body are usually stored in the adipose tissue. It has been shown that this adipose tissue can be mobilized for milk-fat during lactation thus liberating the adipose-stored foreign compounds into the bloodstream and allowing transfer from the blood to milk.

Blood Flow:

The blood flow to the mammary gland is a powerful force capable of transferring significant amounts of foreign compounds and their metabolites into breast milk. Average milk volume produced daily by lactating women with one infant is about 0.8 liter:

Blood flow to the mammary gland is 400 to 500 times greater than the rate of milk formation and thus extensively partitions fat soluble compounds into milk.

Since the breast continuously produces milk but is only emptied every few hours, compounds have sufficient time to accumulate to high levels.

These processes can produce high concentrations of lipid soluble compounds in breast milk even when maternal plasma concentrations are low.

Lactational Transfer Summary:

The potential for transfer of foreign chemicals from mother to infant via milk is a reality and is substantiated in the medical literature. However, exposure of a nursing mother to a toxic chemical or even the presence of that chemical in limited amounts in milk is not necessarily grounds to terminate nursing or alter her occupational status. The critical factor is whether a harmful dose may be received by the infant. This incorporates the additional factor of toxicity into the decision-making process. Thus, added to the factors which effect the partitioning of a foreign compound into milk, is the factor of dose-effect.

Will the infant receive a sufficient dose of the chemical to produce a toxic effect, and what safety factors are desired to reduce the possibility of harmful effects?

B. Hazard Assessment Process

In making a hazard assessment of transfer of chemicals from mother to infant via milk; what is the probability that significant transfer via milk will occur?

Probability of Exposure to Toxic Substances:

This question must be asked in proper context. In all but the most unusual circumstances current AF policies and standards would preclude a toxic exposure to the mother by ensuring that her work exposure conforms to AFOSH Standard 161-8. In most instances, these standards would also keep milk concentrations of foreign chemicals relatively low. Given these circumstances, acute toxicity is unlikely and toxicity is restricted to chronic or subchronic types of toxicity involving cumulative agents.

Various agencies have published guidelines for safe levels of chemicals in food or water. For example, the World Health Organization in 1973 recommended dietary limits which were extrapolated from studies of animal toxicity and epidemiologic investigations in humans of accidental or occupational exposure. Most standards for Allowable Daily Intake (ADI) were developed for adults and the applicability to infants is questionable. Nursing infants may routinely be exposed to higher levels than these ADIs.

For adults, ADIs usually have a 100 to 1000 safety factor. Therefore, the chance of a nursing infant consuming toxic quantities of a compound is relatively low. On the other hand, infants may be more susceptible to certain toxic agents than adults. Poisoning of nursing infants who were not exposed in utero has been reported following accidental exposure of lactating women to high concentrations of hexachlorobenzene and organic mercury compounds. A case of obstructive jaundice has also been recorded in an infant exposed to the dry cleaning agent tetrachloroethylene in breast milk. It has been suggested that women with pesticide or halogenated hydrocarbon residues, at levels above the 90th percentile of the normal or background population, refrain from breast feeding (Wolff).

The establishment of tolerance levels for chemicals implies the existence of a dose response, and a safe level of exposure. For breast milk this means that above a certain concentration a chemical will be consumed by an infant to an extent that is harmful. Similarly, a "no response" level is implied, i.e., below a certain concentration the amount of chemical ingested by an infant is unlikely to be harmful. Both the acute and chronic effects must be considered.

Probability of Transfer to Infant:

The characteristics of a chemical which has a significant potential for milk transfer to an infant have been discussed previously. However, as a practical matter, this information is often not available or is difficult to obtain. Fortunately, it is not necessary to know all the parameters for each chemical because of the limited types of toxicity documented as arising from maternal milk. As discussed above, agents which are cumulative or associated with chronic/subchronic toxicity have the highest probability of producing infant toxicity via milk. With the exception of the heavy metals (Table 3) these agents have two common characteristics: (1) they are highly lipid soluble, and (2) they are eliminated from the body very slowly. By using these two characteristics an initial hazard assessment can be made.

Table 1 contains a compilation of octanol-water partition coefficients. The octanol-water partition coefficient is a standard measure of lipid solubility. Agents with high positive octanol-water partition coefficients are highly lipid soluble and have a high probability of milk transfer.

Table 2 is a compilation of elimination data. This table should be used to estimate the relative effect of chemical elimination rate on transfer via milk. Agents with long elimination times have a higher probability of milk transfer than agents with short elimination times.

Agents such as PCBs are a classic high risk example having both a very high octanol-water partition coefficient (6.0) and a very long elimination time (5-8 months), while an agent such as hydrazine is an example of the low risk category having an octanol-water partition coefficient of -1.07 and a relatively short elimination time (2 hours). Intermediate agents should be evaluated according to estimated dose to the mother. Significant maternal exposures (those approaching the limits of AF Standard 161-8) should raise concern for potential adverse effects to the infant.

Mixtures such as JP-4 or PD 680 must be evaluated according to their chemical composition. Potential chemical exposures of infants via mothers milk would not be to JP-4, but rather to the components of JP-4--decane, nonane, octane, heptane, benzene and others. Thus, the potential hazard of each of these components must be evaluated. For example, the chemical of most concern in JP-4 is benzene. Although benzene has an intermediate octanol-water partition coefficient (1.95), its elimination rate (3 hours) is relatively fast, and most exposures associated with JP-4 are minimal. In addition, benzene is normally present at <<2% in JP-4 and other similar JP fuels. Thus, we would normally not be concerned about occupational JP-4 exposures producing significant amounts of chemicals, primarily benzene, in breast milk.

The hazard evaluation of transfer of occupationally related chemicals from mother to infant should initially involve two steps: (1) evaluation of the toxicity of the chemical involved and (2) evaluation of the probability of transfer (elimination rate and lipid solubility) via milk to the infant. If completion of the initial two steps indicates that a significant possible hazard exists, then consideration of the final assessment step should be made: breast milk analysis for the specific agent(s) in question. This step is necessary to obtain a quantitative assessment. Single milk samples are of very limited value and should be avoided. The decision to evaluate milk contamination must encompass an adequate test plan: one which includes milk samples that reflect the various daily nursing periods and also assesses daily variation in milk composition, preferably encompassing a span of at least one work week. This information would then be combined with the average daily volume of milk consumed by the infant to yield an average daily intake for the chemical in question.

Many of these agents have been identified as food or water contaminants and have an ADI established (Table 2) (Note: The inclusion of these values is for comparison purposes only and doesn't reflect Air Force policy). It is possible to make a comparison between these values and concentration of chemicals in breast milk. Thus, a quantitative estimate of the hazards to the infant can be obtained, and a decision based on this estimate can be made.

Heavy Metals:

Because of their unique characteristics, metals require special consideration when evaluating hazards associated with milk transfer. Table 3 lists occupationally encountered metals and gives toxicity information relating to milk transfer. Milk concentrations which would exceed the ADI have been reported for Mercury, Lead, and Cadmium.

III. CONCLUSION:

In any given workplace there will be essentially three groups of lactating females: (1) females with prior occupational chemical exposure but not exposed during their pregnancy; (2) females who were exposed during their pregnancy, and the infant received in utero exposure; and, (3) females exposed after pregnancy desiring to breast feed.

You must examine all necessary information to determine if she may continue to breast feed without undue risk to her infant. For some chemicals, occupational exposure prior to pregnancy may be as important as current exposures (due to body burden resulting from these prior exposures). Several possible dispositions may be recommended:

She may continue to breast feed but certain job modifications are suggested that will contribute to her child's well being.

She may continue to breast feed only if specific modifications on the job are made that will eliminate or control a significant potential hazard. (This may necessitate a temporary transfer to a different job.)

She may continue to breast feed.

The circumstances dictate she stop breast feeding.

IV. RECOMMENDATIONS:

The recommended procedure for evaluating the hazard of transfer of occupationally encountered chemicals from mother to infant is: (1) evaluation of the workplace to characterize the chemical exposure both qualitatively and quantitatively; (2) evaluate the probability of milk transfer using Tables 1 and 2 or other sources of information containing lipid solubility and elimination rate data; and (3) if a significant hazard is determined to exist and the mother still wishes to nurse, a quantitative analysis of the breast milk should be performed, an average daily milk intake should be determined and an average daily chemical intake should be estimated and compared to the recommended ADI. Where sufficient information is available to apply this method this sequential hazard assessment procedure will allow a reasonable decision to be reached.

Table 1. Lipid Solubility a, b
(Expressed as log octanol/water
partition coefficient [log K_{ow}])

Chemical	log K_{ow}
Acetaldehyde	0.43
Acetic Acid	-0.24
Acetone	-0.24
Acetonitrile	-0.34
Acridine	3.40
Acrylic Acid	0.37
Acrylonitrile	-0.92
Allyl Alcohol	0.17
P-Aminobenzene	2.98
P-Aminobenzoic Acid	0.95
Ammonia	-1.29
Amylacetic Acid	3.13
Aniline	0.94
Anthracene	4.45
Azobenzene	3.82
Benzene	1.95
Benzoic Acid	1.87
Benzylamine	1.09
Biphenyl	3.76
2-Biphenylphenyl Ether	5.55
1,3-Butanediol	-1.02
N-Butanol	0.88
Butylbenzene	4.11
N-Butylchloride	2.39
2,3-Butylene Glycol	-0.92
Caffeine	-0.07
Captan	2.35
Carbon Disulfide	2.00
Carbon Tetrachloride	2.64
Chlorobenzene	2.84
Chloroform	1.97
Chlorophenol	2.83
Chloropicrin	2.44
Chlorotoluene	3.31
Chlorpyrifos	5.10
P-DDT	6.19
Cresol	1.99
Decanoic Acid	4.09
Dichloroacetic Acid	0.73

Table 1. Lipid Solubility (Cont.)

Dichlorfenthion	5.14
3,4-Dichloroanaline	2.69
Dichlorobenzene	3.38
2,4-Dichlorophenoxyacetic Acid	2.81
Diethanolamine	-1.43
2,2-Dimethyl,1-Propanol	1.36
Dinitrobenzene	1.50
2,4-Dinitrophenol	1.53
Diphenyl Oxide	4.20
Dioxane	-0.42
Ethanol	-0.32
Ethylchloride	1.54
Ethylene Glycol	-1.93
Ethylenethiourea	-0.66
Formaldehyde	0.00
Formic Acid	-0.54
Glycerol	-2.56
Glycerol Monoacetate	-0.29
Hexachlorobenzene	6.18
Hexamethyl Phosphoric Triamide	0.28
Hexamethylene Tetramine	-2.15
1,6-Hexanediol	-0.72
Hexanol	2.03
2,4-Hexanedione	2.81
Hydrazine	-1.07
Hydrocyanic Acid	0.65
Hydrogen Chloride	0.25
Hydrogen Sulfide	1.20
Indene	2.92
Isopropylamine	-0.03
Malonic Acid	-0.79
Malonitrile	0.13
Menthol	3.31
Mercuric Chloride	0.06
Methoxyethanol	-0.71
Methyliodide	1.69
Methylethylketone	0.28
Naphthalene	3.37
1-Naphthol	2.98
Naphthylamine	2.24
Nicotine	1.17

Table 1. Lipid Solubility (Cont.)

Nitrobenzene	1.87
Nitroethane	0.18
Nitroglycerin	2.20
Nitromethane	-0.13
1-Nitronaphthalene	3.19
Nitrophenol	1.89
1-Nitropropane	0.65
Octanol	3.15
Oxalic Acid	-0.74
Paraldehyde	0.49
Parathion	2.15
Pentachlorophenol	5.01
1,5-Pentanediol	-0.89
Phenanthrene	4.46
Phenol	1.47
Phenylhydrazine	1.25
Picric Acid	2.03
4,4'-Polychloronated Biphenyl (PCB)	5.58
2,4,5,2'5'-PCB	6.11
2,4,5,2'4'5-PCB	6.72
1,2-Propylenediamine	-1.77
Propylene Glycol	-1.36
Pyridine	0.64
Quinone	0.20
Ronnel	4.87
1,1,2,2-Tetrachloroethylene	2.88
2,3,7,8-Tetrachlorodibenzodioxin	7.02
Thymol	3.30
Toluene	2.71
Tributylamine	1.52
Trichloroacetic Acid	1.17
2,4,5-Trichlorophenol	3.72
1,2,3-Trihydroxybenzene	0.26
Triethanolamine	-1.54
Trimethylamine	0.27
2,4,6-Trinitrobenzoic Acid	0.36
Urea	-2.75
Xylene	3.15
Xylidine	1.85

[a]Values were obtained from several sources including Leo et al., Freed et al., and Neely. Values were derived from Leo et al. by determining the mean of multiple entries where multiple entries occurred.

Table 1. Lipid Solubility (Cont.)

[b]Large positive values indicate high lipid solubility. Chemical should be transmitted to a significant extent via milk fat. Large negative values indicate high water solubility. Chemical will be present to a limited extent in milk. Example: Hexachlorobenzene (log K_{ow} = 6.18) will be readily transmitted via milk to infant, while hydrazine (log K_{ow} = -1.07) will not be transmitted to a significant extent via milk to the infant.

Table 2: Elimination and ADI Data for Selected Chemicals

CHEMICAL	ELIMINATION[a]	MILK/[b],e PLASMA	ALLOWABLE DAILY[c,d,e,g] INTAKE (μg)
Anthracene	f	---	4.4×10^{-4}
Benzene	3.0 hr	1.2	9.6×10^{-3}
Caffeine	3.5 hr	0.5	---
Carbon disulfide	0.9 hr	1.0	7.7×10^{1}
Chlordane	21 day	---	5.0×10^{0}
Chloroform	1.5 hr	---	2.7×10^{-2}
Cyanide	Rapid	---	6.0×10^{2}
DDT	10-20 yr	6.5	2.5×10^{0}
Dichlorobenzene	24 hr	---	6.7×10^{1}
Dichloroethane (1,2-)	2.5 hr	---	1.4×10^{-1}
Dichlorofluoromethane	9.4 min	---	4.0×10^{-1}
Dinitrophenol (2,4-)	2.5 hr	---	1.0×10^{1}
Endrin	24 hr	---	5.0×10^{2}
Ethanol	1.5 hr	0.9	---
Ethylene glycol	3 hr	---	3.2×10^{2}
Halothane	1 hr	3.5	4.1×10^{1}
Hydrazine	2 hr	---	2.6×10^{-1}
Methylene chloride	2.4 hr	---	2.7×10^{-2}
Naphthalene	f	---	4.4×10^{-4}
Nicotine	30-60 min	---	1.3×10^{0}
Nitrobenzene	86.0 hr	---	2.9×10^{3}
Pentachlorophenol	30 hr	---	1.5×10^{2}
PBB	5-8 mo	3.0	5.0×10^{0}
PCB	5-8 mo	7.0	5.0×10^{0}
Phenanthrene	f	---	4.4×10^{-3}
Phenol	3.4 hr	---	5.0×10^{2}
Tetrachloroethylene	70.0 hr	3.0	1.3×10^{-1}
Toluene	12.0 hr	---	8.7×10^{-1}
Trichloroethylene	30 min	---	2.5×10^{3}
Trichlorophenol	20 hr	---	5.0×10^{2}
Xylene	3.8 hr	---	1.1×10^{3}

[a]Cralley and Cralley, Doull, et al., Keller, et al., and Ambient Water Quality Criteria Document. Estimated half-lives.

[b]Breast milk may contain significant amounts of the compound if milk plasma ratio is greater than one, and levels in breast milk are likely to exceed ADI.

[c]ADI are based on EPA recommendations or ACGIH TLV values. (The AF doesn't endorse these standards. They are for comparative purposes only.)

Table 2. Elimination and ADI Data for Selected Chemicals (Cont.)

[d]For carcinogens an excess risk factor of 10^{-6} has been used to establish the ADI.

[e]Wolff (1983).

[f]Elimination is highly variable; dependent on induction or inhibition of liver metabolic enzymes.

[g]Adjusted to 5 kg infant from adult recommendation

Table 3: Elimination and ADI Data for Selected Metals

Compound	Maternal Elimination Data	Limit ADI[a,g,i,m]	(Comment)[a-f,l]
Aluminum	(Unknown)	None Established	No adverse effects reported from lactational transfer of Al in animals (Yokel).
Arsenic	5-6d	3.6×10^{-4} µg	Lactational transfer limited.
Beryllium	Fairly Rapid	.03 µg	Poorly adsorbed when given orally, principally an inhalation hazard.
Cadmium[h]	One Year	1.7 µg	No adverse effects reported from lactational transfer of Cd in animals.
Chromium	Cleared Slowly	10.0 µg[k]	Essential dietary element. Principally an inhalation hazard as hexavalent Cr.
Copper	Fairly Rapid	None Established	Essential dietary element. Maternal homeostatic mechanisms should prevent excess lactational transfer.
Lead[h]	60d	36 µg[k]	Higher uptake in infants compared to adults. No reported toxicity due solely to lactational transfer.[j]
Nickel	< 1 day	2.2 µg	Reported in cow's milk. No reports concerning lactational toxicity.
Mercury[h]	40d (organic) 70d (inorganic)	2.0 µg[k]	Toxicity due to lactational transfer has been reported.
Zinc	200d	None Established	Essential dietary element. Maternal homeostatic mechanisms should prevent excess lactational transfer

NOTE: See footnotes on next page.

Table 3. Elimination and ADI Data for Selected Metals (Cont.)

[a]EPA Ambient Water Quality Criteria Documents.

[b]Zielhuis, et al.

[c]Casarett and Doull.

[d]Hunt.

[e]Drinking Water and Health.

[f]Underwood.

[g]Derived from WHO ADI recommendations and EPA and other agency recommendations for drinking water standards. The AF does not endorse these standards, they are offered for comparative purposes. It is anticipated that these recommendations will change as additional toxicity information becomes available. The most common recommendations should be used.

[h]Breast milk levels have been reported to exceed ADI (Based on 5 kg infant ingesting 0.7 l/day).

[i]For carcinogens, an excess risk factor of 10^{-6} has been used to establish the ADI.

[j]Average content of cow's milk 40 µg/l.

[k]Wolff

[l]Some metals are cleared rapidly from the blood but are retained for a very long time by the kidneys. Thus, although overall maternal body burden may be large, transfer via milk to an infant would be very limited.

[m]Adjusted to 5 kg infant from adult recommendation.

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Appendix
(Definitions)

Acute toxicity - toxicity resulting from single or multiple exposures occurring within a short time (24 hours).

Allowable Daily Intake (ADI) - the amount of material consumed daily which produces no adverse effect.

Body burden - the amount of material retained in the body following exposure.

Chronic toxicity - toxicity resulting from multiple or continuous exposure occuring over a long time (Usually one year or more).

Elimination - composite effects of all processes which remove a chemical from the body or change the chemical within the body.

Ionization constant (pka) - negative logarithm of the acid dissociation constant. The state of ionization depends on the pka and the ambient pH.

Lactational transfer - transfer of chemicals from the mother's body to the infant in milk.

Lipid soluble - solubility in fatty material: fatty acids, neutral fats, soaps, waxes. Cellular material is composed of protein-lipid materials.

Metabolism - chemical transformation of compounds foreign to an organism by various enzymes present in that organism.

No response level - dose of chemical which produces no adverse effect.

Protein binding - reversible association of chemical with plasma proteins.

Subchronic toxicity - toxicity resulting from multiple or continuous exposure over an intermediate period of time (90 days).

Tolerance levels - dose of chemical which produces no adverse effect.

Distribution List

	Page
HQ USAF/SGPA (LTC Goker) Bolling AFB DC 20332-6188	2
USAFSAM/TSK Brooks AFB TX 78235-5001	2
Defense Technical Information Center Cameron Station Alexandria VA 22319	2
HQ AFLC/SGPB Wright-Patterson AFB OH 45433-5001	10
HQ AFSC/SGPB Andrews AFB DC 20334-5000	10
HQ ATC/SGPB Randolph AFB TX 78150-5001	10
HQ AAC/SGPB Elmendorf AFB AK 99506-5300	10
HQ MAC/SGPB Scott AFB IL 62225-5001	10
HQ PACAF/SGPB Hickam AFB HI 96853-5001	10
HQ SPACECMD/SGPB Peterson Field CO 80914-5000	10
HQ SAC/SGPB Offutt AFB NE 68113-5001	25
HQ TAC/SGPB Langley AFB VA 23665-5001	10
HQ USAFE/SGPB APO New York 09012-5000	10

END

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