X. APPENDIX III

RECOMMENDED RESEARCH

There is clear need for information in the following areas in order to set a limit for chlorine which is more reliably based on demonstrated dose-response relationships:

(a) Documentation of human response in the range between perception of odor and marked discomfort at concentrations below 5.0 ppm, with assessment of possible increasing tolerance effects with increasing duration of exposure.

(b) Epidemiologic studies correlating long-term effects with chlorine exposures in excess of 0.3 ppm.

(c) Studies correlating the combined effects of cigarette smoking and chlorine exposure.

(d) Animal studies of myocardial response to graded exposures to chlorine.

(e) Animal studies of the effect of low doses of chlorine on the animals' capacity to resist infection.

(f) Animal studies of the effects of mixtures of chlorine with other chemicals.

XI. APPENDIX IV

MATERIAL SAFETY DATA SHEET

The following items of information which are applicable to a specific product or material shall be provided in the appropriate block of the Material Safety Data Sheet (MSDS).

The product designation is inserted in the block in the upper left corner of the first page to facilitate filing and retrieval. Print in upper case letters as large as possible. It should be printed to read upright with the sheet turned sideways. The product designation is that name or code designation which appears on the label, or by which the product is sold or known by employees. The relative numerical hazard ratings and key statements are those determined by the rules in Chapter V, Part B, of the NIOSH publication, An Identification System for Occupationally Hazardous Materials. The company identification may be printed in the upper right corner if desired.

(a) Section I. Product Identification

The manufacturer's name, address, and regular and emergency telephone numbers (including area code) are inserted in the appropriate blocks of Section I. The company listed should be a source of detailed backup information on the hazards of the material(s) covered by the MSDS. The listing of suppliers or wholesale distributors is discouraged. The trade name should be the product designation or common name associated with the material. The synonyms are those commonly used for the product, especially formal chemical nomenclature. Every known chemical designation or

competitor's trade name need not be listed.

(b) Section II. Hazardous Ingredients

The "materials" listed in Section II shall be those substances which are part of the hazardous product covered by the MSDS and individually meet any of the criteria defining a hazardous material. Thus, one component of a multicomponent product might be listed because of its toxicity, another component because of its flammability, while a third component could be included both for its toxicity and its reactivity. Note that a MSDS for a single component product must have the name of the material repeated in this section to avoid giving the impression that there are no hazardous ingredients.

Chemical substances should be listed according to their complete name derived from a recognized system of nomenclature. Where possible, avoid using common names and general class names such as "aromatic amine," "safety solvent," or "aliphatic hydrocarbon" when the specific name is known.

The "%" may be the approximate percentage by weight or volume (indicate basis) which each hazardous ingredient of the mixture bears to the whole mixture. This may be indicated as a range or maximum amount, ie, "10-40% vol" or "10% max wt" to avoid disclosure of trade secrets.

Toxic hazard data shall be stated in terms of concentration, mode of exposure or test, and animal used, ie, "100 ppm LC50-rat," "25 mg/kg LD50-skin-rabbit," "75 ppm LC man," or "permissible exposure from 29 CFR 1910.1000," or, if not available, from other sources of publications such as the American Conference of Governmental Industrial Hygienists or the

American National Standards Institute Inc. Flammable or reactive data could be flash point, shock sensitivity, or other brief data indicating nature of the hazard.

(c) Section III. Physical Data

The data in Section III should be for the total mixture and should include the boiling point and melting point in degrees Fahrenheit (Celsius in parentheses); vapor pressure, in conventional millimeters of mercury (mmHg); vapor density of gas or vapor (air = 1); solubility in water, in parts/hundred parts of water by weight; specific gravity (water = 1); percent volatiles (indicated if by weight or volume) at 70 Fahrenheit (21.1 Celsius); evaporation rate for liquids or sublimable solids, relative to butyl acetate; and appearance and odor. These data are useful for the control of toxic substances. Boiling point, vapor density, percent volatiles, vapor pressure, and evaporation are useful for designing proper ventilation equipment. This information is also useful for design and deployment of adequate fire and spill containment equipment. The appearance and odor may facilitate identification of substances stored in improperly marked containers, or when spilled.

(d) Section IV. Fire and Explosion Data

Section IV should contain complete fire and explosion data for the product, including flash point and autoignition temperature in degrees Fahrenheit (Celsius in parentheses); flammable limits, in percent by volume in air; suitable extinguishing media or materials; special firefighting procedures; and unusual fire and explosion hazard information. If the product presents no fire hazard, insert "NO FIRE HAZARD" on the line

labeled "Extinguishing Media."

(e) Section V. Health Hazard Information

The "Health Hazard Data" should be a combined estimate of the hazard of the total product. This can be expressed as a TWA concentration, as a permissible exposure, or by some other indication of an acceptable standard. Other data are acceptable, such as lowest LD50, if multiple components are involved.

Under "Routes of Exposure," comments in each category should reflect the potential hazard from absorption by the route in question. Comments should indicate the severity of the effect and the basis for the statement, if possible. The basis might be animal studies, analogy with similar products, or human experiences. Comments such as "yes" or "possible" are not helpful. Typical comments might be:

> Skin Contact--single short contact, development of burns; prolonged or repeated contact, pain and tissue destruction.
>
> Eye Contact--burning and tearing

"Emergency and First Aid Procedures" should be written in lay language and should primarily represent first aid treatment that could be provided by paramedical personnel or individuals trained in first aid.

Information in the "Notes to Physician" section should include any special medical information which would be of assistance to an attending physician including required or recommended preplacement and periodic medical examinations, diagnostic procedures, and medical management of overexposed workers.

(f) Section VI. Reactivity Data

The comments in Section VI relate to safe storage and handling of hazardous, unstable substances. It is particularly important to highlight instability or incompatibility to common substances or circumstances such as water, direct sunlight, steel or copper piping, acids, alkalies, etc. "Hazardous Decomposition Products" shall include those products released under fire conditions. It must also include dangerous products produced by aging, such as peroxides in the case of some ethers. Where applicable, shelf life should also be indicated.

(g) Section VII. Spill or Leak Procedures

Detailed procedures for cleanup and disposal should be listed with emphasis on precautions to be taken to protect workers assigned to cleanup detail. Specific neutralizing chemicals or procedures should be described in detail. Disposal methods should be explicit including proper labeling of containers holding residues and ultimate disposal methods such as "sanitary landfill," or "incineration." Warnings such as "comply with local, state, and federal antipollution ordinances" are proper but not sufficient. Pertinent specific local requirements shall be identified.

(h) Section VIII. Special Protection Information

Section VIII requires specific information. Statements such as "Yes," "No," or "If necessary" are not informative. Ventilation requirements should be specific as to type and preferred methods. Respirators shall be specified as to type and NIOSH or US Bureau of Mines approval class, ie, "Supplied air," "Organic vapor canister," "Suitable for dusts not more toxic than lead," etc. Protective equipment must be

specified as to type and materials of construction.

(i) Section IX. Special Precautions

"Precautionary Statements" shall consist of the label statements selected for use on the container or placard. Additional information on any aspect of safety or health not covered in other sections should be inserted in Section IX. The lower block can contain references to published guides or in-house procedures for handling and storage. Department of Transportation markings and classifications and other freight, handling, or storage requirements and environmental controls can be noted.

(j) Signature and Filing

Finally, the name and address of the responsible person who completed the MSDS and the date of completion are entered. This will facilitate correction of errors and identify a source of additional information.

The MSDS shall be filed in a location readily accessible to workers potentially exposed to the hazardous material. The MSDS can be used as a training aid and basis for discussion during safety meetings and training of new employees. It should assist management by directing attention to the need for specific control engineering, work practices, and protective measures to ensure safe handling and use of the material. It will aid the safety and health staff in planning a safe and healthful work environment and in suggesting appropriate emergency procedures and sources of help in the event of harmful exposure of employees.

MATERIAL SAFETY DATA SHEET

I PRODUCT IDENTIFICATION	
MANUFACTURER'S NAME	REGULAR TELEPHONE NO. EMERGENCY TELEPHONE NO.
ADDRESS	
TRADE NAME	
SYNONYMS	

II HAZARDOUS INGREDIENTS		
MATERIAL OR COMPONENT	%	HAZARD DATA

III PHYSICAL DATA			
BOILING POINT 760 MM HG		MELTING POINT	
SPECIFIC GRAVITY (H_2O=1)		VAPOR PRESSURE	
VAPOR DENSITY (AIR=1)		SOLUBILITY IN H_2O % BY WT	
% VOLATILES BY VOL		EVAPORATION RATE (BUTYL ACETATE=1)	
APPEARANCE AND ODOR			

IV FIRE AND EXPLOSION DATA

FLASH POINT (TEST METHOD)		AUTOIGNITION TEMPERATURE	
FLAMMABLE LIMITS IN AIR, % BY VOL.	LOWER		UPPER
EXTINGUISHING MEDIA			
SPECIAL FIRE FIGHTING PROCEDURES			
UNUSUAL FIRE AND EXPLOSION HAZARD			

V HEALTH HAZARD INFORMATION

HEALTH HAZARD DATA

ROUTES OF EXPOSURE

INHALATION

SKIN CONTACT

SKIN ABSORPTION

EYE CONTACT

INGESTION

EFFECTS OF OVEREXPOSURE

ACUTE OVEREXPOSURE

CHRONIC OVEREXPOSURE

EMERGENCY AND FIRST AID PROCEDURES

EYES

SKIN

INHALATION

INGESTION

NOTES TO PHYSICIAN

VI REACTIVITY DATA

CONDITIONS CONTRIBUTING TO INSTABILITY

INCOMPATIBILITY

HAZARDOUS DECOMPOSITION PRODUCTS

CONDITIONS CONTRIBUTING TO HAZARDOUS POLYMERIZATION

VII SPILL OR LEAK PROCEDURES

STEPS TO BE TAKEN IF MATERIAL IS RELEASED OR SPILLED

NEUTRALIZING CHEMICALS

WASTE DISPOSAL METHOD

VIII SPECIAL PROTECTION INFORMATION

VENTILATION REQUIREMENTS

SPECIFIC PERSONAL PROTECTIVE EQUIPMENT

RESPIRATORY (SPECIFY IN DETAIL)

EYE

GLOVES

OTHER CLOTHING AND EQUIPMENT

IX SPECIAL PRECAUTIONS

PRECAUTIONARY
STATEMENTS

OTHER HANDLING AND
STORAGE REQUIREMENTS

PREPARED BY _____

ADDRESS _____

DATE _____

XII. APPENDIX V

PULMONARY FUNCTION ABBREVIATIONS USED BY AUTHORS

DLCO	diffusing capacity of lung for carbon monoxide
FEV	forced expiratory volume
FEV 0.5	forced expiratory volume at 0.5 second
FEV 1	forced expiratory volume at 1 second
FEV 3	forced expiratory volume at 3 seconds
FRC	functional residual capacity
FVC	forced vital capacity
Glaw	lower airway conductance in liter/sec/cm H2O/liter
MMF	maximum midexpiratory flow rate
MVV	maximum voluntary ventilation
PaCO2	partial pressure of carbon dioxide in arterial blood
PaO2	partial pressure of oxygen in arterial blood
PO2	partial pressure of oxygen
PEFR	peak expiratory flow rate
Raw	airway resistance
RV	residual volume
TLC	total lung capacity
VC	vital capacity

XIII. SELECTED TABLES AND FIGURE

TABLE XIII-1

CHEMICAL AND PHYSICAL PROPERTIES OF CHLORINE

Molecular weight	70.906 g/mole
Vapor pressure, 21 C	6.0 kg/sq cm gage (85.3 psig)
Specific volume, 21 C, 1 atm	0.34 liters/g
Boiling point, 1 atm	-34 C
Freezing point (bp), 1 atm	-101 C
Specific gravity of gas at 0 C, 1 atm (air = 1)	2.49
Specific gravity of liquid at 20 C	1.41
Density of gas at 0 C, 1 atm	3.214 g/liter
Density of liquid at 0 C, 3.65 atm	1468 g/liter
Critical temperature	144 C
Critical pressure	78.64 kg/sq cm absolute (76.1 atm)
Latent heat of vaporization at bp	68.8 calories/g
Solubility in water at 20 C, 1 atm	7.30 g/liter
Color of gas	Yellowish green
Color of liquid	Clear amber
Flammability	Nonflammable
Reactivity	Highly reactive
Odor	Disagreeable, strong, suffocating, pungent, irritating, characteristic

Adapted from reference 105

TABLE XIII-2

OCCUPATIONS WITH POTENTIAL EXPOSURE TO CHLORINE

Aerosol propellant makers	Iron detinners
Alkali salt makers	Iron dezinkers
Aluminum purifiers	Laundry workers
Benzene hexachloride makers	Methyl chloride makers
Bleachers	Paper bleachers
Bleaching powder makers	Petroleum refinery workers
Bromine makers	Phosgene makers
Broommakers	Photographic workers
Carpetmakers	Pulp bleachers
Chemical synthesizers	Rayon makers
Calcium chloride makers	Refrigerant makers
Chlorinated solvent makers	Rubber makers
Chlorinated hydrocarbon insecticide makers	Sewage treaters
	Silver extractors
Chlorine workers	Sodium hydroxide makers
Colormakers	Submarine workers
Disinfectant makers	Sugar refiners
Dyemakers	Sulfur chloride makers
Ethylene glycol makers	Swimming pool maintenance workers
Ethylene oxide makers	
Flour bleachers	Tetraethyl lead makers
Fluorocarbon makers	Textile bleachers
Gasoline additive workers	Tin recovery workers
Gold extractors	Vinyl chloride makers
Inkmakers	Vinylidene chloride makers
Iodine makers	Water treaters
	Zinc chloride makers

Adapted from reference 3

TABLE XIII-3

RECOMMENDED ALKALINE SOLUTIONS FOR ABSORBING CHLORINE

Chlorine Container Capacity	Caustic Soda		Soda Ash		Hydrated Lime*	
	100%	Water		Water		Water
lb (net)	lb	gal	lb	gal	lb	gal
100	125	40	300	100	125	125
150	188	60	450	150	188	188
2000	2500	800	6000	2000	2500	2500

*Hydrated lime solution must be continuously and vigorously agitated during chlorine absorption.

From reference 130

TABLE XIII-4

SURVIVAL OF GUINEA PIGS INOCULATED WITH MYCOBACTERIUM TUBERCULOSIS, WITH AND WITHOUT EXPOSURE TO CHLORINE

Inoculation Route	Average Days (and Range) Survived			
	TB Exposure Only	TB Exposure Before Chlorine	TB Exposure After Chlorine	Chlorine Exposure Only
Subcutaneous	200 (142-275)	145 (110-175)	123 (49-177)	
Conjunctival	250 (220-280)	205 (160-250)	190 (172-208)	
Intra-tracheal	99 (84-114)	70 (48-107)	------	
Ganglionic	215 (193-232)	203 (110-264)	139 (127-169)	
None	------	------	------	>300

From reference 59

TABLE XIII-5

CHLORINE EXPOSURE-EFFECT DATA
--HUMAN STUDIES

Reference	Exposure Concentration (ppm)	Number Exposed	Route of Administration	Effects
16	0.027 (mean) 0.014-0.054 (range)	20	Inhalation	Tickling of nose
16	0.058 (mean) 0.04-0.097 (range)	20	"	Tickling in throat
16	0.06-0.2	3	Inhalation of concentrations increasing from 0.0 to 1.3 ppm over 50 minutes	Itching in the nose
17	0.09	10	Inhalation	Tickling and stinging in the nose (4), cough (1), dryness in throat (1)
17	0.2	13	"	Slight tickling in the nose and throat (7), cough (1), sensations in the ocular conjunctiva (3)
17	0.3	4	Inhalation of concentrations increasing from 0.0 to 1.8 ppm	Stinging in the throat (3)
17	0.36	4	"	Sensation of choking (1)

TABLE XIII-5 (Continued)

CHLORINE EXPOSURE-EFFECT DATA
--HUMAN STUDIES

Reference	Exposure Concentration (ppm)	Number Exposed	Route of Administration	Effects
16	0.452 (mean) 0.35-0.72 (range)	19	Inhalation	Burning of conjunctiva, pain after 15 minutes.
16	0.5	3	Inhalation of concentrations increasing from 0.0 to 1.3 ppm over 50 minutes	Cough
16	1.0	3	Inhalation of concentrations increasing from 0.0 to 1.0 ppm over 35 minutes	Headache
17	1.0	10	Inhalation	Tickling and stinging in the nose (6), scratchiness and dryness in the throat (4), dull sensation in the teeth and a slight metallic taste (1), headache and pressure, burning of ocular conjunctiva and outer skin, coughing, constriction of breathing (1)
16	1.0-1.3	1	Inhalation of concentrations increasing from 0.0 to 1.0 ppm over 35 minutes	Severe shortness of breath and cough with violent headache

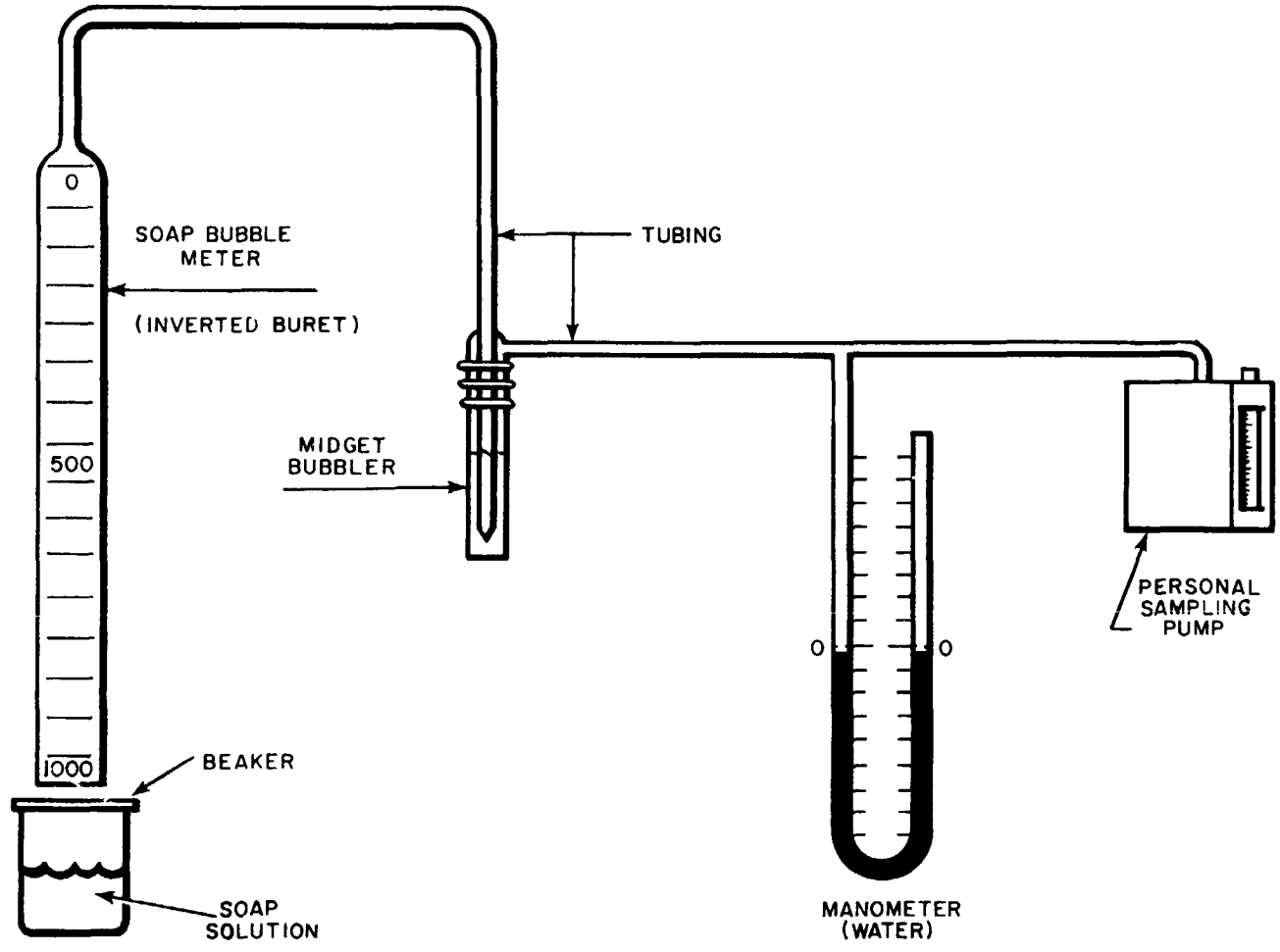
TABLE XIII-5 (Continued)

CHLORINE EXPOSURE-EFFECT DATA
--HUMAN STUDIES

Reference	Exposure Concentration (ppm)	Number Exposed	Route of Administration	Effects
38	1.3	1	Inhalation for 7 minutes	Burning sensation in eyes and nose
17	1.4	4	Inhalation of concentrations increasing from 0.0 to 1.8 ppm	Neck pain, substernal pain, conjunctival irritation (1), headache (1)
38	2.5	1	Inhalation for 5-16 minutes	Severe burning in eyes, itching in mouth and throat, nasal congestion, heavy coughing, breathing pains
38	3.5-4.0	1	Inhalation	Immediate burning of eyes, nasal congestion

Figure XIII-1

CALIBRATION SETUP FOR PERSONAL SAMPLING PUMP WITH MIDGET BUBBLER



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