XVI. APPENDIX VII

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, eg, "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. Flashpoint, shock sensitivity, or similar descriptive data may be used to indicate flammability, reactivity, or similar hazardous properties of the material.

(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 F (21.1 C); 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 flashpoint 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, no adverse effects likely; prolonged or repeated contact, possibly mild irritation.

Eye Contact--some pain and mild transient irritation; no corneal scarring.

"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 employees.

(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 employees 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. Specific procedures 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 MSHA approval class, ie, "Supplied air," "Organic vapor canister," etc. Protective equipment must be specified as to type and materials of construction.

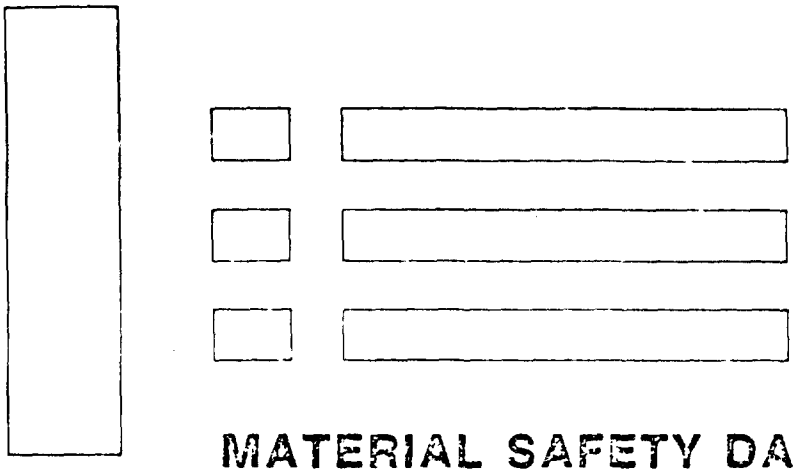
(i) Section IX. Special Precautions

"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 employees exposed to the hazardous substance. 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

TABLE XVII-1

PHYSICAL AND CHEMICAL PROPERTIES OF VINYL HALIDE COMPOUNDS

Property	Vinyl Chloride	Ref	Vinylidene Chloride	Ref	Vinyl Bromide	Ref	Vinyl Fluoride	Ref	Vinylidene Fluoride	Ref
Molecular formula	CH_2:CHCl	287	CH_2:CCl2	301	CH_2:CHBr	337	CH_2:CHF	130	CH_2:CF_2	130
Formula weight	62.50	338	96.95	301	106.96	304	46.046	130	64.038	130
Appearance	Colorless gas	287	Clear, colorless liquid	114	Colorless gas	337	Colorless gas	114	Colorless gas	114
Odor/Threshold (ppm)	Sweet	339	Sweet/500-1,000	114	Pungent	304	Faint, ethereal	340	Faint, ethereal	8
Boiling point	-13.9 C	287	31.56 C	301	15.85 C	300	-72.0 C	130	-85.7 C	130
Melting point	-153.7 C	287	-122.5 C	301	-137.8 C	127	-160 C	130	-144 C	129
Specific gravity	0.99 at -25 C	338	1.218 at 20 C	114	1.529 at 11 C	341	0.853 at -26 C	341	-	
Density liquid (g/ml)	0.9121 at 20 C	287	1.2132 at 20 C	301	1.522 at 20 C	304	0.636 at 21 C	130	0.659 at 21 C	251
Vapor pressure (mmHg)	2,580 at 20 C	114	495 at 20 C	339	1,000 at 20 C	342	19,129 at 21 C**	130 343	27,763 at 21 C**	130 343
Vapor density (air = 1)	2.15	339	3.34	301	3.7	304	1.56	114	2.2	114
Density of saturated air	-		2.8	301					-	
Refractive index	1.4066 at 10 C	287	1.42468 at 20 C	301	1.4410 at 20 C	343	1.35 at 20 C	340	-	
Molar refractivity*	15.66	229 344	20.44	229 344	18.58	229 344	10.65	229 344	10.43	229 344
Viscosity	0.2734 centipoise at -20 C	10	0.3302 centipoise at 20 C	301	0.376 centipoise at 0 C	360	0.15 centipoise at 15.6 C (liquid)	130	-	
Specific heat (cal/g)	Liquid, 0.38 at 20 C; gas at 1 atm and 25 C, 0.205	10	0.275	345	Gas at 1 atm and 25 C, 0.1241	337	-		Gas at 25 C, 14.37 cal/mole	251
Heat of vaporization (at boiling point)	79.84 cal/g	10	6,257 cal/mole	301	54.9 cal/g	304	3.97 Kcal/mole	340	980 cal/mole	251
Heat of combustion	286.2 Kcal/mole	339	261.93 Kcal/mole	301					-	
Heat of polymerization	22.9 Kcal/mole	339	18 Kcal/mole	301	18 Kcal/mole	300	-		-	
Heat of fusion	18.14 cal/g at melting point	10	1,557 cal/mole	301	12.3 cal/g	304			-	
Flashpoint (open cup)	-78 C	287	15 C	114	None	304	-		-	
Flammable limits (in air)	3.6 -33.0%	339	7 - 16% at 28 C	301	9 - 15%	300	2.6 - 21.7%	130	5.5 - 21.3%	130
Dielectric constant	6.26 at 17.2 C	10	4.67 at 16 C	301	Liquid at 5 C, 5.63; gas at 100 C, 1.01	342	20.2 at -81 C, 100,000Hz	130	-	
Dipole moment (μ)	1.45	343	1.34	343	1.42	343	1.43	343	1.38	343
Solubility										
Water (g/100 ml)	0.11 at 24 C	10	0.25 at 25 C	345	0.565 at 25 C	300	Insoluble	340	0.018 at 25 C	130
Organic solvents	-		Soluble	114	Soluble in most	300	-		-	
Alcohol	Soluble	287	Soluble	301	Soluble	300	Soluble	340	Soluble	343
Ether	Very soluble	287			"	300	"	340	Very soluble	343
CCl4	"	287	Very soluble	301	"	300	-		-	
Benzene	"	287	Soluble	301	"	343	-		-	
Acetone	-		"	301	"	343	Soluble	343	-	

TABLE XVII-1 (CONTINUED)

PHYSICAL AND CHEMICAL PROPERTIES OF VINYL HALIDE COMPOUNDS

Property	Vinyl Chloride	Ref	Vinylidene Chloride	Ref	Vinyl Bromide	Ref	Vinyl Fluoride	Ref	Vinylidene Fluoride	Ref
Σ electronegativity of substituents	9.3	346	10.2	346	9.1	346	10.3	346	12.2	346
Log P (calculated octanol/water partition coefficient) †	0.60	229, 347	0.73	229, 347	0.74	229, 347	0.16	229, 347	-0.15	229, 347
Σσ * (substituent on vinyl) ††	1.05	229, 232, 346	2.10	229, 232, 346	1.02	229, 232, 346	1.10	229, 232, 346	2.20	229, 232, 346
Σσ I (substituent on vinyl) ††	0.47	229, 232, 346	0.94	229, 232, 346	0.45	229, 232, 346	0.52	229, 232, 346	1.04	229, 232, 346
ΣσR (substituent on vinyl) £	-0.24	229, 346	-0.48	229, 346	-0.22	229, 346	0.44	229, 346	-0.88	229, 346
IR C = C stretch cm^{-1}	1,620	348	1,560	348	1,610	348				
Symmetry of epoxide (1=y,0=N) ‡‡	0	1,229	0	1,229	0	1,229	0	1,229	0	1,229
Chi # *	0.99	229, 349, 350, 351	1.35	229, 349, 350, 351	0.99	229, 349, 350, 351	.99	229, 349, 350, 351	1.35	229, 349, 350, 351
Conversion Factors (760 mm Hg and 25 C)										
1.00 mg/cu m *	0.391	114	0.252 ppm	114	0.2285 ppm	127	0.532 ppm	114	0.382 ppm	114
1 ppm *	2.56 mg/cu m		3.97 mg/cu m		4.38 mg/cu m		1.88 mg/cu m		2.62 mg/cu m	

** Calculated using lbs/sq in multiplied by 51.7 to obtain values in mm Hg [130,343]

* Calculated [229] using additivity rules for structural fragments as described by Hansch [349]

† Calculated [229] using fragment constants and rules for additivity developed by Leo et al. [351] These values may express the duration and relative order of the lipid water solubility ratios better than the absolute magnitude of the ratios

†† Chemical substituent constant measuring electronic inductive effects. Values were calculated [229] directly from data in references [348] and [232] and represent the sum of the effects of all halo substituents on the ethylene bond. Relevance of these values in evaluating reactivity of vinyl compounds has not been established empirically

£ Chemical substituent constant measuring resonance effects. Values represent the sum of the effects of the halo substituents on the ethylene bond and were calculated [229] directly from data in reference [348] Relevance evaluating reactivity of vinyl compounds has not been empirically established

‡‡ 1 indicates symmetry, 0 indicates asymmetry [229]. Bunse and Henschler [1] hypothesized that asymmetrical intermediates would be less stable and more reactive than symmetrical ones

Calculated value [229] describing bonding state of the molecule. Chi increases with increased branching of the carbon chain. Chi values presented here consider all atoms to be carbon, thus, they differentiate between multiple and single substituents rather than between effects of different types of substituents

TABLE XVII-2

SYNONYMS FOR VINYL HALIDES

Vinyl Chloride	Vinyl Bromide
Chloroethene	Bromoethene
Chloroethylene	Bromoethylene
Chlorethene	VBr
Chlorethylene	
Ethylene monochloride	
Monochloroethene	Vinyl Fluoride
Monochloroethylene	
Vinyl chloride monomer	Fluoroethylene
Vinyl C monomer	Fluoroethene
VC	VF
VCM	
Triclene	

Vinylidene Chloride	Vinylidene Fluoride
as-Dichloroethylene	1,1-Difluoroethylene
asym-Dichloroethylene	1,1-Difluoroethene
uns-Dichloroethylene	alpha,alpha-Difluoroethylene
1,1-Dichloroethene	VDF
1,1-Dichloroethylene	Isotron 1132A
Vinylidene dichloride	Genetron 1132A
alpha,alpha-Dichloroethylene	
Vinylidene chloride monomer	
VDC	
Sconatex	

Adapted from references 8,251,287,298,301,341,343,352-354

TABLE XVII-3

OCCUPATIONS WITH POTENTIAL EXPOSURE TO VINYL HALIDES

Chemical-synthesis workers
Equipment cleaners
Equipment repairers
Maintenance workers
Monomer-containing aerosol producers
Monomer-containing aerosol users
Monomer loaders and unloaders
Monomer production workers
Monomer samplers and gagers
Monomer transport workers
Polymer compounders
Polymer fabricators
Polymer loaders and unloaders
Polymer packagers
Polymer processors
Polymer production workers
Polymer transport workers
Polymer control-laboratory workers
Warehouse workers

Adapted from references 130,279,284,287,294,300,301,355,356

TABLE XVII-4

REPORTED CASES OF ANGIOSARCOMA OF THE LIVER IN VINYL CHLORIDE POLYMERIZATION WORKERS*

Country	Case No.	Birth Date	First VC or PVC Exposure	Diagnosis of Angio-sarcoma	Age at Diag-nosis	Years from First Ex-posure to Diagnosis	Total Years Expo-sure	Date of Death
Belgium	01	00-00-00	00-00-00	00-00-00	00	00	00	06-29-76
Canada	01**	12-15-13	00-00-44	00-00-55	41	10	11	09-02-55
"	02**	03-06-14	00-00-43	00-00-57	43	14	14	12-21-57
"	03**	08-26-19	00-00-41	00-00-62	42	21	20	03-22-62
"	04**	04-05-19	00-00-45	00-00-67	48	22	22	01-21-68
"	05**	05-07-11	00-00-44	00-00-68	57	24	05	07-05-68
"	06**	12-15-19	00-00-47	00-00-71	51	24	23	04-10-71
"	07**	11-09-19	00-00-46	00-00-72	53	26	25	12-24-72
"	08	05-13-20	00-00-61	00-00-73	53	12	05	06-12-73
"	09	07-19-21	00-00-46	00-00-74	53	28	26	09-04-74
"	10	05-16-15	00-00-53	00-00-76	61	23	14	04-00-77
Czechoslovakia	01**	00-00-28	00-00-57	00-00-73	46	16	16	00-00-74
"	02**	00-00-26	00-00-51	00-00-66	40	15	15	00-00-66
Federal Republic of Germany	01**	06-04-30	10-01-56	09-19-68	38	12	12	01-25-69
"	02**	07-26-31	10-14-57	09-25-70	39	13	12	12-14-71
"	04	09-04-30	04-16-57	00-00-74	44	17	17	11-25-74
"	05**	01-01-32	12-16-62	00-00-75	43	13	12	01-09-75
"	07**	09-29-26	04-15-54	00-00-75	49	21	12	11-13-75
"	08**	10-19-17	04-19-54	00-00-75	58	22	21	12-25-75
"	09**	12-13-34	12-02-59	06-16-76	42	17	15	Alive

TABLE XVII-4 (CONTINUED)

REPORTED CASES OF ANGIOSARCOMA OF THE LIVER IN VINYL CHLORIDE POLYMERIZATION WORKERS*

Country	Case No.	Birth Date	First VC or PVC Exposure	Diagnosis of Angiosarcoma	Age at Diagnosis	Years from First Exposure to Diagnosis	Total Years Exposure	Date of Death
Federal Republic of Germany	11	Awaiting Details						
France	01**	04-15-24	01-00-46	02-18-67	43	21	19	02-19-67
"	02	06-03-11	07-06-59	01-08-75	63	15	12	01-24-75
"	03**	00-00-19	00-00-46	01-00-75	55	29	29	06-29-75
"	04**	01-27-27	10-19-49	01-04-76	49	26	26	01-04-76
"	05**	01-29-38	00-00-65	04-00-76	38	11	10	05-13-76
"	06**	04-14-34	00-00-58	09-00-76	42	18	17	09-12-76
"	07	00-00-27	07-01-50	07-00-76	49	26	23	07-02-76
"	08	00-00-00	00-00-00	00-00-00	00	00	00	01-30-77
Great Britain	01**	00-00-01	00-00-46	12-00-72	71	26	20	12-00-72
"	03	06-02-37	02-00-66	00-00-74	37	09	04	12-24-74
Italy	02**	11-13-29	00-00-57	12-13-72	43	15	06	12-00-72
"	03**	03-14-20	00-00-53	07-10-75	55	22	21	07-10-75
Japan	01	08-01-22	04-00-53	08-21-74	52	22	22	10-24-75
Norway	01**	12-23-15	03-00-50	12-20-71	56	22	21	01-04-72
Sweden	01**	06-23-27	08-14-51	02-00-70	43	19	18	10-20-70
"	03	Awaiting Details						
"	04	"	"					
United States	01**	10-17-23	12-09-48	03-03-73	49	22	16	03-03-73
"	02**	08-19-33	11-15-55	05-00-70	37	14	13	09-28-71

TABLE XVII-4 (CONTINUED)

REPORTED CASES OF ANGIOSARCOMA OF THE LIVER IN VINYL CHLORIDE POLYMERIZATION WORKERS*

Country	Case No.	Birth Date	First VC or PVC Exposure	Diagnosis of Angio-sarcoma	Age at Diag-nosis	Years from First Ex-posure to Diagnosis	Total Years Expo-sure	Date of Death
United States	03**	05-25-15	11-28-45	12-19-73	58	28	28	12-19-73
"	04**	01-15-24	07-06-52	08-13-67	43	15	15	01-07-68
"	05**	01-25-12	06-13-44	04-09-64	52	20	18	04-09-64
"	06**	00-00-29	01-17-62	02-00-74	45	12	12	07-24-75
"	07**	05-03-22	08-27-44	00-00-68	45	24	18	03-23-68
"	08**	05-06-20	10-07-46	08-00-61	41	15	15	08-29-61
"	09**	11-08-31	09-09-54	03-01-74	43	17	17	03-00-75
"	10**	08-16-13	06-12-51	05-00-68	55	17	17	05-10-68
"	11**	05-27-09	10-14-46	03-00-70	61	23	23	03-16-70
"	12**	11-17-18	09-13-49	05-02-69	50	20	15	05-02-69
"	13**	12-01-21	08-19-44	05-00-74	52	30	30	07-04-74
"	16**	11-04-27	05-08-50	00-00-69	41	17	4	03-27-69
"	17**	05-06-31	06-23-55	10-11-74	43	19	19	Alive
"	18**	04-22-28	09-15-54	00-00-75	46	21	13	11-02-75
"	19**	00-00-15	00-00-43	06-19-75	60	32	32	Alive
"	20**	08-31-17	00-00-55	01-30-76	58	21	18	01-30-76
"	21**	00-00-10	12-00-46	00-00-77	67	30	22	01-02-77
"	22**	10-02-23	00-00-49	01-00-76	52	27	27	12-04-76
"	23**	00-00-23	09-08-58	00-00-00	50	00	14	04-06-73
"	24**	00-00-17	00-00-39	05-27-77	60	38	26	05-27-77
"	25**	08-07-10	09-00-47	03-10-77	67	30	20	03-10-77
Yugoslavia	01**	04-05-14	00-00-53	04-08-73	59	20	20	04-08-73
"	02**	11-15-31	00-00-50	07-12-73	42	23	18	07-12-73

*"00" indicates unknown data.
**Diagnosis was microscopically confirmed.

Adapted from reference 61

TABLE XVII-5

BREAKTHROUGH VOLUMES FOR VINYL CHLORIDE ON VARIOUS SORBENTS

	Mesh	Concentration of Vinyl Chloride (μg/liter)	Sampling Rate (liter/min)	Breakthrough Volume* (liter)
Chromosorb 101-103	80/90	500	1.00	<0.1
Chromosorb 106-107	60/80	500	0.20	<0.1
Tenax GC	35/60	500	0.20	<0.1
Silica gel	20/40	130	0.20	<0.1
Silica gel with 1% $AgNO_3$	20/40	130	0.20	<0.1
Molecular Sieve, 5A	30/40	500	0.20	2.0**
Carbopak A	45/60	500	0.20	<0.1
Carbopak B	45/60	500	0.20	<0.1
Carbosieve B	45/60	500	0.20	2.8
Dow Carbon XF4175L	20/40	6.5	0.20	5.7**
"	20/40	6.5	0.15	11.1
"	20/40	6.5	0.10	15.0
"	20/40	6.5	0.05	21.2**
Petroleum Charcoal, SKC-104	20/40	6.5	0.10	7.7***
Coal Charcoal, BPL	20/40	6.5	0.10	8.2**
Coconut Shell Charcoal:				
MSA-6	20/40	500	1.00	0.9
"	20/40	500	0.20	2.4**
"	20/40	500	0.05	5.2
"	20/40	130	0.20	3.4
"	20/40	6.5	0.20	5.7
"	20/40	6.5	0.10	10.3****
"	20/40	6.5	0.05	10.7
SKC-105	20/40	6.5	0.10	10.6
PCB	20/40	6.5	0.10	8.1**

*Values from a single experiment unless otherwise indicated
**Average of values from two experiments
***Average of values from three experiments
****Average of values from four experiments

Adapted from reference 244

TABLE XVII-6

RETENTION DATA FOR VINYL CHLORIDE ON CHARCOAL TUBES*

Concentration of Vinyl Chloride (ppm)	Sample Rate (ml/min)	Mass VCM Flowrate (μg/min)	Retention Volume** (liter)	Retention Time** (min)	Total Mass** (μg)
5	50	0.639	10.0	200	127.9
5	100	1.278	9.8	98	125.2
5	150	1.916	29.3	195	373.6
25	50	3.19	7.9	158	504
25	100	6.38	22.8	228	1,456
25	150	9.58	20.5	137	1,312
50	50	6.38	9.0	180	1,285
50	100	12.78	18.1	181	2,311
50	150	19.16	14.8	98.7	1,891

*Standard (150-mg charcoal) tubes from MSA
**At 10% breakthrough from front section of tube

Adapted from reference 254

TABLE XVII-7

RELATIVE RETENTION TIMES FOR COMPOUNDS POTENTIALLY INTERFERING WITH GAS CHROMATOGRAPHIC ANALYSIS OF VINYL CHLORIDE*

Compound	Chromosorb 102**		Porapak Q**	0.4% Carbowax 1500 on Carbopak A***
	100 C	145 C	100 C	Ambient Temperature
Methane	0.15	-	0.05	0.20
Ethane	0.21	-	-	0.29
Ethene	0.21	0.33	-	0.26
1,1-Difluoroethylene	-	0.33	-	0.63
Propene	-	0.62	0.46	0.63
Propane	0.54	-	0.52	0.63
Methylacetylene	-	-	0.56	-
Methyl chloride	0.63	-	0.57	0.45
1,1-Difluoroethane	-	0.51	-	-
Chlorodifluoromethane	-	0.53	-	-
Cyclopropane	-	-	0.59	-
Formaldehyde	-	-	0.62	-
1-Chloro-1,1-difluoroethane	-	0.92	-	-
Acetaldehyde	0.93	-	0.95	0.77
Freon 114	-	1.21	-	-
Isobutane	1.22	-	-	-
Isobutylene	1.37	1.25	-	-

TABLE XVII-7 (CONTINUED)

RELATIVE RETENTION TIMES FOR COMPOUNDS POTENTIALLY INTERFERING WITH GAS CHROMATOGRAPHIC ANALYSIS OF VINYL CHLORIDE*

Compound	Chromosorb 101**		Porapak Q**	0.4% Carbowax 1500 on Carbopak A***
	100 C	145 C	100 C	Ambient Temperature
Methanol	-	-	-	1.38
1,3-Butadiene	1.57	1.27	-	-
1-Butene	1.43	1.30	-	1.83
Vinyl methyl ether	-	1.36	-	-
Trans-2-butene	1.57	1.38	-	2.92
Ethyl chloride	1.70	-	-	1.54
Cis-2-butene	1.73	1.43	-	-
Vinyl bromide	-	1.85	-	-
1,1-Dichloroethylene	2.00	-	-	-

*Retention of vinyl chloride = 1.0
**6 feet x 1/8 inch, 80/100 mesh
***6 feet x 1/8 inch

Adapted from reference 264

TABLE XVII-8

COMPARISON OF GAS CHROMATOGRAPHY DETECTORS
FOR VINYL CHLORIDE ANALYSIS

Detector	Specificity	Approximate Detection Limit (g)
Flame ionization	Organic compounds	1.0×10^{-10}
Electron capture	Halides	2.0×10^{-9}
Electroconductivity (Hall detector)	"	7.0×10^{-11}
Chemiluminescence	Olefins	2.0×10^{-9}
Mass spectroscopy (specific ion monitoring)	M/e 62 and 64 ions	$1\text{-}2.0 \times 10^{-11}$

Adapted from reference 264

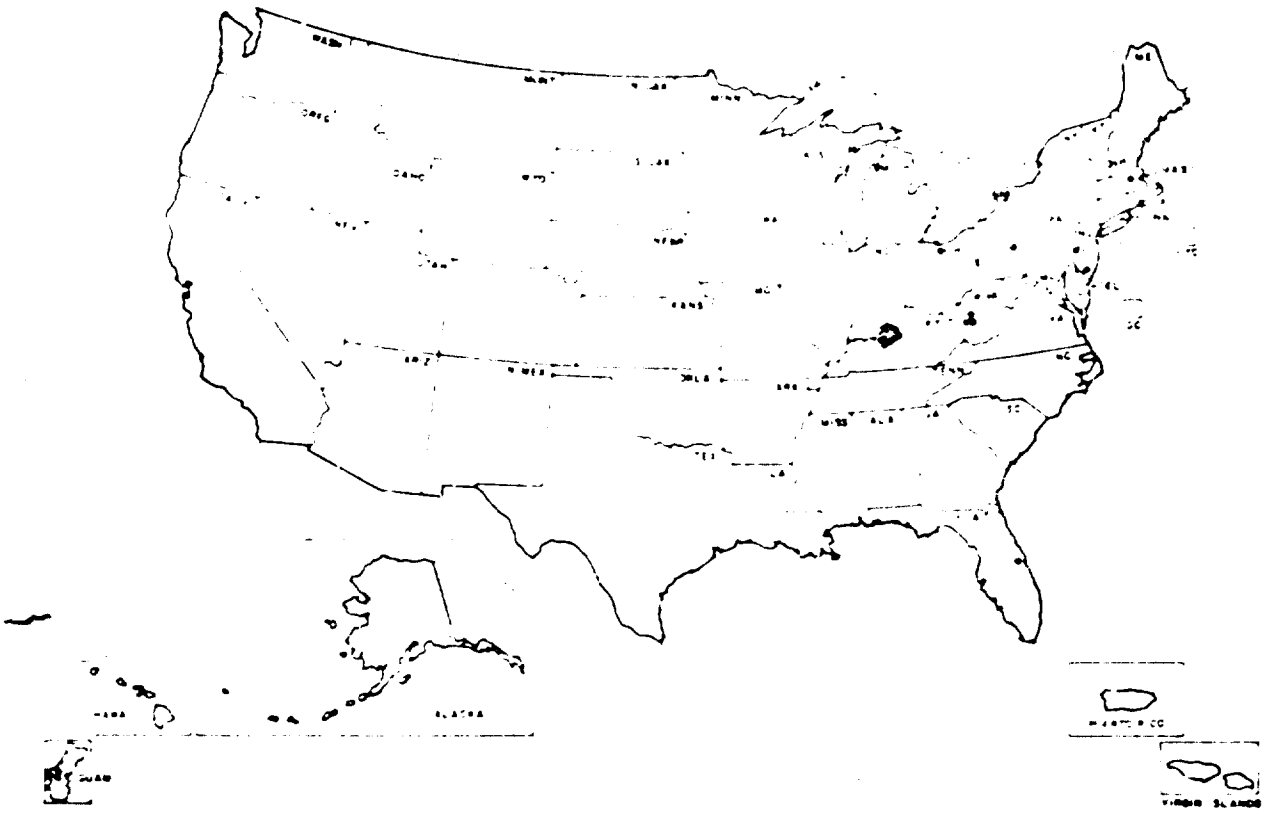


FIGURE XVII-1

GEOGRAPHIC DISTRIBUTION* OF 22 CASES OF ANGIOSARCOMA OF THE LIVER IN US VINYL CHLORIDE POLYMERIZATION WORKERS, 1961-1977**

* By place of residence at time of death or on date of diagnosis, if still alive

** Preliminary results; includes only pathologically confirmed cases in Center for Disease Control review; 1 additional case is pending

Adapted from reference 63

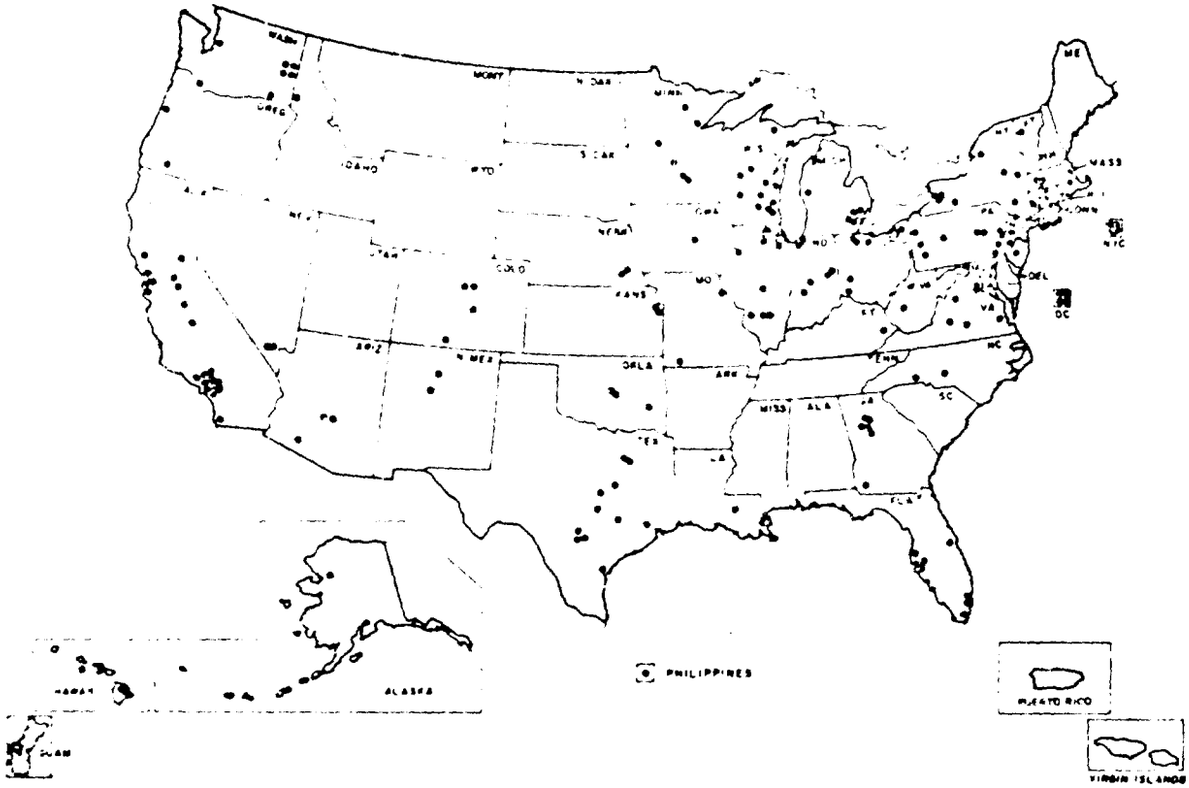


FIGURE XVII-2

GEOGRAPHIC DISTRIBUTION* OF 200 CASES OF ANGIOSARCOMA OF THE LIVER IN US RESIDENTS NOT OCCUPATIONALLY EXPOSED TO VINYL CHLORIDE, 1943-1977**

* By place of residence at time of death or on date of diagnosis, if still alive

** Preliminary results includes only pathologically confirmed cases in Center for Disease Control review; evaluation of additional cases is pending

Adapted from reference 53

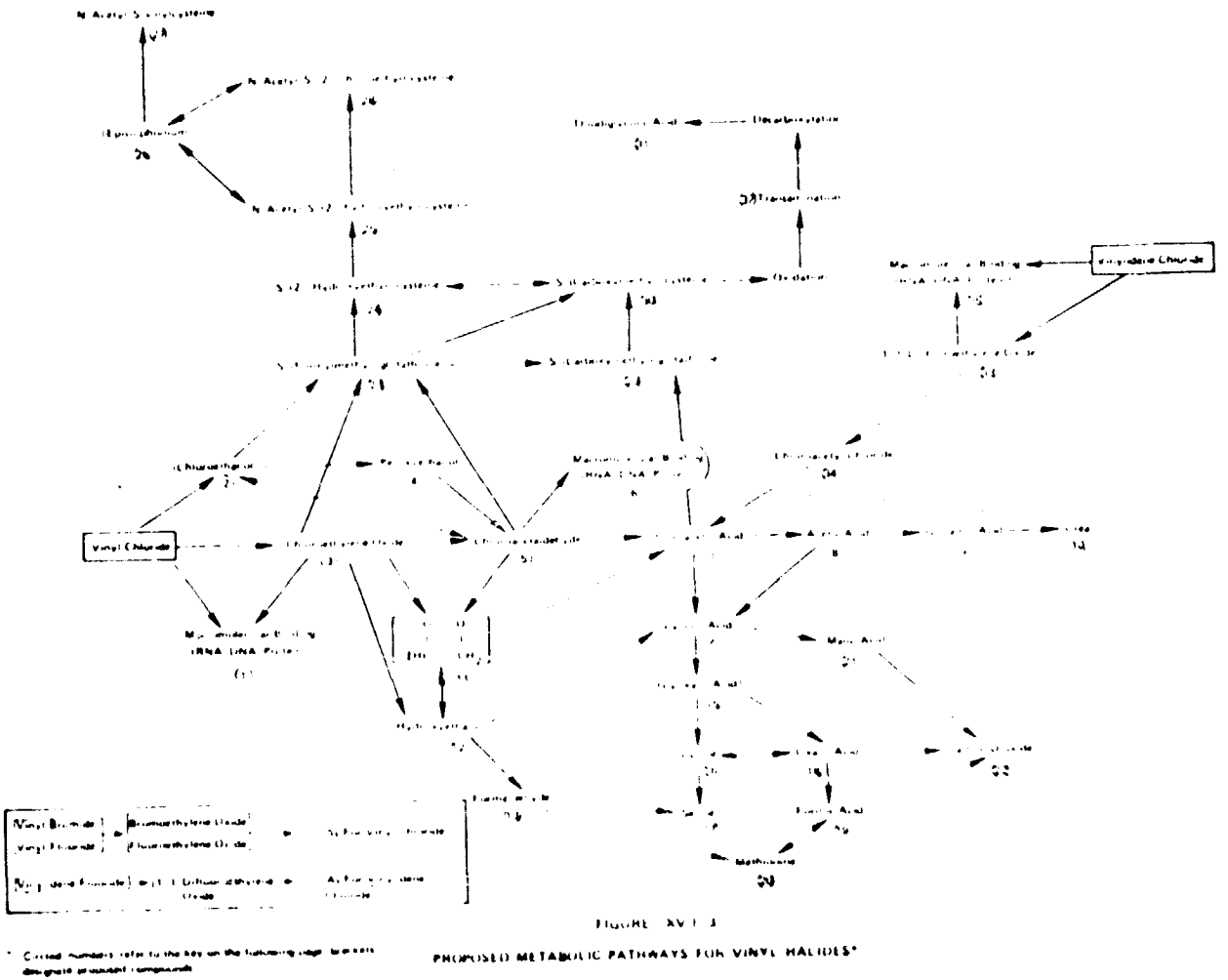


FIGURE XVI.3

PROPOSED METABOLIC PATHWAYS FOR VINYL HALIDES*

* Circled numbers refer to the key on the following page. Brackets designate proposed compounds.

KEY TO FIGURE XVII-1

Compound Process*	Identification	Species	Exposure	Reference
1	In vivo	Rat	Inhalation	202
	"			215
	In vitro		Liver homogenate	212
				214
				216
				5
			Kidney homogenate	213
				177
				216
2	In vivo	Rat	Oral	5
			Liver homogenate	5
4	In vitro			193
		Mouse		5
	Proposed			5
				177
				175
				216
				218
6				217
	In vivo	Rat	Oral	193
	In vitro		Liver homogenate	5
	Proposed			5
				6
				5
				195
				177
		Mouse	ip	198
	In vitro	Rat	Liver perfusate	194
Vinylidene chloride	Proposed			219
				1
4				196
7	In vivo	Rat	Oral, ip, iv	5
	In vitro		Liver extract**	193
12	In vivo		Oral, ip, iv	5
13	Proposed			5
22				196
23				5
				195
24	In vivo	Mouse	ip	198
15	Proposed			196
16	In vivo	Rat	Oral, ip, iv	5
	In vitro		Liver extract**	193
17	In vivo	"	Oral, ip, iv	5
18	"	Mouse	ip	198
19	Proposed			196

Compound Process*	Identification	Species	Exposure	Reference
20.	In vivo	Rat	Oral, ip, iv	5
21.	Proposed			196
2.	In vivo	Rat	Oral, ip, iv	5
			Inhalation	6
			Oral	177
Vinylidene chloride			Inhalation	216
			Oral	217
				193
			Inhalation	6
			Oral	177
			Inhalation	175
Vinylidene chloride				216
			Inhalation, oral	218
			Oral	217
26.	Proposed			195
27.	In vivo	Rat	Oral	195
28.			Oral, ip, iv	5
			Oral	195
29.				193
	In vitro		Liver homogenate	193
30.	In vivo		Inhalation	195
		Mouse	ip	198
	In vitro	Rat	Liver extract**	193
31.	In vivo	"	Oral, ip, iv	5
	"	"	Oral	177
	"	"	Inhalation	195
	"	"	"	175
		Mouse	ip	198
Vinylidene chloride		Rat	Inhalation	216
			Inhalation, oral	218
			Oral	217
32. (Mechanism)	Proposed			195
33. Vinylidene chloride)	"			219
	"			1
34. (Vinylidene chloride	"			219
	"			1
35. (Vinylidene chloride)	In vivo	Rat	Inhalation	216
	"	"	"	219
	"	"	Oral	217
	"	Mouse	ip	117

*Numbers refer to circled numbers in Figure XVII-1, on preceding page.
**Incubated with kidney homogenate

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