



Building B-101

Dow U.S.A.

The Dow Chemical Company
2301 N. Brazosport Blvd.
Freeport, Texas 77541-3257

OCCUPATIONAL HEALTH SUMMARY REPORT

LOCATION: UNIT V (VINYL CHLORIDE PRODUCTION)

PERIOD COVERED: April 4 - May 3, 1994

MEDICAL:

C. K. Browdy MD

8-24-94

C. K. Browdy, M.D.
Occupational Health Associate

Date

INDUSTRIAL HYGIENE:

J. Jurgiel

8-29-94

J. Jurgiel
Industrial Hygienist

Date

REVIEWED:

D. R. Correll

9/6/94

D. R. Correll
Unit Manager

Date

cc: L. J. Burmeier
J. H. Saunders, M.D.
Summary File

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OCCUPATIONAL HEALTH SUMMARY REPORT

This is a voluntary participation program. The group population is seventy. Thirty-one individuals have current information and were not examined at this time. One individual is in the Management Examination Program. Thirty-seven individuals were examined between April 4, 1994, and May 3, 1994, for a 97% participation rate.

The Chemical and Physical Agent Inventory (CPAI) for Unit V, the vinyl chloride monomer production plant, shows that potential exposures are low. This plant is not yet in operation. All individuals are followed on the periodic core examination.

There were thirty-six audiograms done. There was one standard threshold shift as defined by the OSHA Noise Standard. This individual is not in the Texas Operations Hearing Conservation Program.

Three individuals have limitation of respirator usage based on initial screening of the medical examination data. Please see Attachment A for medical limitation of respirator usage. If these medical restrictions interfere with an individual's job requirements, further evaluation at the Occupational Health Department should be arranged to fully assess the need for medical limitation of respirator usage.

Individuals with life-style factors that are amenable to medical or dietary intervention include the following: eight smokers, twenty-nine individuals who are overweight, four individuals with uncontrolled hypertension, and fifteen individuals with elevated cholesterol levels. Please see Attachment B for a graphic representation of this data. Assistance in modification of these life-style risk factors can be obtained by contacting the Health Promotion Department (238-4334).

Attachments

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ATTACHMENT A

August 24, 1994

MEDICAL LIMITATION OF RESPIRATOR USAGE

The following three individuals may wear respirators for escape purposes only:

The following sixty-seven individuals have no medical limitation of respirator usage:

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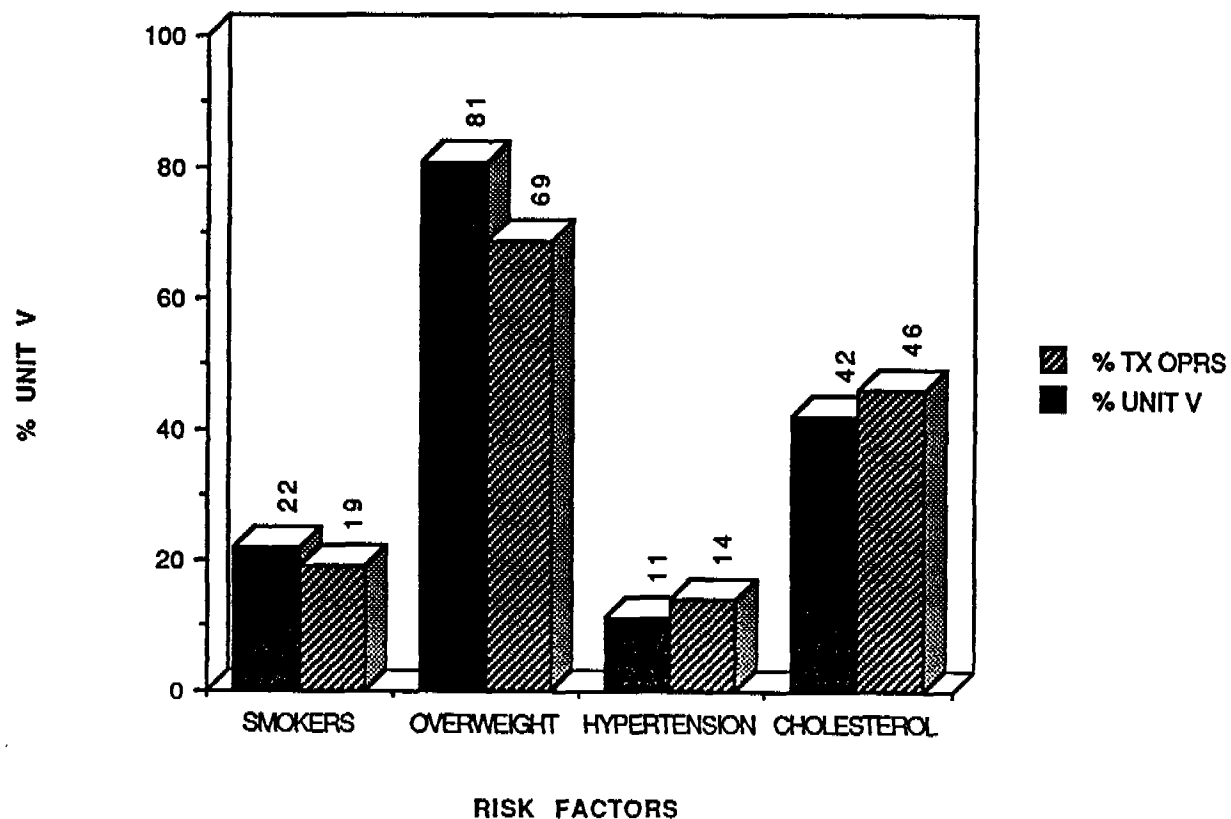
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REDACTED

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August 24, 1994

Data from "UNIT 5 8/94"



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1993-95 OCCUPATIONAL HEALTH PROGRAM
UNIT 5/VINYL CHLORIDE, OC-501**MONITORING PROGRAM****1. RATIONALE**

To fulfill OSHA requirements of the vinyl chloride and benzene standards, establish a monitoring base and to evaluate the need for any additional engineering controls, initial monitoring will be conducted immediately after plant startup. Chemicals evaluated will include vinyl chloride, benzene, ethylene dichloride, and methylene chloride. Respiratory protection will be used for any job tasks with a significant potential for exposure to concentrations above the acceptable guidelines. Respiratory protection will be continued until monitoring data has proven levels to be below acceptable exposure standards.

Area noise level monitoring will be conducted as new equipment is installed to determine the need for hearing protection, additional engineering controls and identify any job classifications that may need to be included in the hearing conservation program. Personnel monitoring will be conducted for job classifications where 8-hour TWA exposures may exceed 85 dBA. After plant startup, a comprehensive area and personnel noise survey will be conducted to identify all areas with noise levels greater than 85 dBA and determine if any job classifications need to be included in the hearing conservation program.

2. SAMPLING STRATEGY

When Unit 5 reaches the final stages of construction, job classifications will be evaluated periodically to determine the need for chemical and/or noise monitoring. Monitoring will be conducted on an as needed basis until startup. As soon as possible after startup a comprehensive noise and chemical survey will be conducted. The sampling strategy (number of samples and job classifications) will be determined at that time.

3. SAMPLING METHODS

Sampling for vinyl chloride, ethylene dichloride, methylene chloride, and benzene will be conducted using 1 gram charcoal tubes and air sampling pumps. Pumps will be calibrated both before and after use at 50 cc/min for 8-hour TWA samples and 200 cc/min for excursion samples (as outlined in DLI-IHM-83-25A). Analysis will be performed by the Industrial Hygiene Laboratory.

Personal noise levels will be measured using Quest noise dosimeters (Model M-7B) and area noise levels will be measured using a Quest noise level meter (Model 215). All dosimeters and meters will be calibrated both before and after use.

4. QUALITY CONTROL AND EQUIPMENT

Routine quality control procedures shall be an integral part of the sampling and analysis procedures and functions. These shall include:

- a. Routinely introduced sampling of blanks and spikes (known content) along with other samples for analysis
- b. Routine checking, calibrating, and maintaining in good working order all equipment and instruments. Air sampling pumps will be calibrated both before and after use.
- c. Routine checking of procedures and results.
- d. Participation in Dow's Analytical Proficiency Testing (APT) Program.

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1993-95 OCCUPATIONAL HEALTH PROGRAM
UNIT 5/VINYL CHLORIDE, OC-501

MONITORING PROGRAM (CONT.)

5. EVALUATION CRITERIA

Agent	Exposure Guideline	Excursion Guide	Source*
Vinyl Chloride	1 ppm	5 ppm-STEL	OSHA-PEL
Ethylene Dichloride	10 ppm	---	ACGIH-TLV
Benzene	1 ppm	2 ppm	Proposed OSHA PEL
Methylene Chloride	1 ppm	5 ppm-STEL	OSHA-PEL
Noise	50 ppm	---	ACGIH-TLV
	---	90 dBA-Ceiling	Dow IHG
	90 dBA (8-hr TWA)	---	OSHA-PEL
	85 dBA (8-hr TWA)	---	OSHA-Action Level

- * OSHA-PEL = Occupational Safety and Health Administration - Permissible Exposure Limit
- ACGIH-TLV = American Conference of Governmental Hygienists-Threshold Limit Value
- Dow-IHG = Dow Industrial Hygiene Guideline

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Distribution List for Unit V VCM Exposure Plan

Unit V Staff

Others

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Unit V Industrial Hygiene Monitoring
VCM Exposure Follow Up Program

Introduction

This document is intended to explain the responses of Unit V personnel to the results of personnel monitoring data showing levels of Vinyl Chloride in above the "Action Level" as defined in OSHA 1910.1017 Vinyl Chloride.

Areas Addressed

Information

Monitoring results were communicated to the individuals involved immediately upon receipt of the information or at first availability of the individuals.

Sampling Techniques

Sampling techniques were critiqued and suggestions to the individuals were made.

Lab Hoods

A review of the effectiveness of the Laboratory Vent Hoods was conducted and action was taken to correct any deficiencies.

Monitoring Plans

The frequency of monitoring of personnel showing VCM levels above the "Action Level" was increased and specific tasks noted.

Sampling Devices

Tracking of problems associated with the sampling devices was begun and the supplier of these devices was contacted for recommendations on the problems with leaking seals.

Program Plans

Action	By Whom	Date
1. Determine by leak testing with an HNU which bombs are leaking and track the frequency of failures.		Beginning 10/27/94 on PM schedule.
2. Replace Technova sample "bombs" on the samples with the highest frequency of failures.		As needed based on the data collected in #1.
3. Continue monitoring of people one day per week during the sampling process until data shows this is no longer needed.		Beginning week of 10/31/94.

Unit V Industrial Hygiene Monitoring
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Unit V Industrial Hygiene Monitoring
VCM Exposure Follow Up Program

A Vinyl Monitoring/Technova Follow Up meeting was held February 1, 1995. Attendees were

Agenda Items were:

Review of written plans and action items
Review of monitoring data
Review of maintenance on Technova samplers
Brainstorm additional items

Action Items resulting from the meeting were:

Replace Vinyl "bombs" with new type - no plungers.
Establish a ppm program based on leak test data.
Meet again in 6 months to review status of Technovas.

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UNIT V VINYL CHLORIDE EXPOSURE

OSHA

The Occupational Safety and Health Administration Standard for Vinyl Chloride states:

1. No employee may be exposed to Vinyl Chloride at concentrations greater than 1 PPM averaged over any eight hour period.
2. No employee may be exposed to Vinyl Chloride at concentrations greater than 5 PPM averaged over any period not exceeding 15 minutes.
3. No employee may be exposed to Vinyl Chloride by direct contact with liquid Vinyl Chloride.

The OSHA rule simply means "that we must never knowingly be exposed to vinyl chloride in concentrations above the prescribed limits, and that every precautionary measure is taken to keep from being over-exposed unknowingly".

NOTE: A detailed explanation of the air monitor system, specifications and operating discipline are maintained in the Environmental Section of Toolbox.

AIR MONITOR ALARM

Some of the situations that may arise and the correct procedures are:

Response to a vinyl chloride air monitor alarm:

1. Notify everyone in the plant via an intercom as to the location of the air monitor alarm and wind direction (stack monitor alarms are not considered leaks, but should be announced over the intercom).
2. Either a HNU portable analyzer or an organic vapor portable (OVA) reading of 500 PPMV of VCM constitutes a leak under TACB Permit C 19041 Section 7H. Because of the HNU analyzer limiting range (1000 PPM), the OVA is the portable analyzer of choice when pinpointing VCM leaks as defined by TACB Permit C 19041.
3. Respiratory equipment (5 or 30 minutes SCBAs) must accompany the person who is attempting to locate the leak. Respiratory equipment must be worn if more than 1 PPM is determined by the portable detector:
 - a. for concentrations 1 PPM to 3,600 PPM, a self-contained breathing apparatus must be used. Because of the limited air supply, 5 minute air packs should be used for escape only.

Continued on next page

**AIR MONITOR
ALARM, cont.**

- b. at concentrations greater than 3,600 PPM but less than 10,000 PPM do not enter the area except for purposes of rescue or prevention of greater hazard. (36,000 PPM in air is the L.E.L. for Vinyl Chloride.)
4. Barricade leak area so that exposures outside of the barricaded area will be less than 1 PPM Vinyl Chloride.

**LEAK DETECTION
ELIMINATION
PLAN**

The Unit V Leak Detection/Elimination Plan must be followed.

NOTE: Action for any positive reading identified as Vinyl Chloride.

1. Locating the leak source.
2. Defining boundaries of the area of high vinyl concentration.
3. Restricting access to the high vinyl area with barricades, tape, and signs.
4. Requiring the use of air supplied respiratory equipment be mandatory for entry into the area. 5 minute escape packs are not acceptable for entry.
5. Notifying the appropriate supervisor.
6. Monitoring equipment cleaning procedures if maintenance is necessary.
7. Resurveying the leak site after repairs are finished.

**EQUIPMENT
OPENING**

The National Emission Standard for Hazardous Air Pollutants (NESHAP) states: "Before opening any equipment for any reason, the quantity of Vinyl Chloride is to be reduced so that the equipment contains no more than 2.0 percent by volume Vinyl Chloride or 0.0950M*3 (25 gallons) of Vinyl Chloride, whichever is larger, at standard temperature and pressure".

**NON-ROUTINE
SAMPLING**

Any non-routine sampling must first be evaluated for proper compliance with OSHA rules before proceeding with sampling and a procedure written.

OCS Unit V
Basic Safety Orientation

Background

This unit orientation module is designed to allow temporarily assigned personnel to receive basic unit specific safety orientation without repeating information already received.

**Department
Safety Rules**

All Texas Operations Safety Rules and Standards apply in this Unit and are expected to be followed. In addition the following departmental rule extracts apply to all personnel working in Unit V.

- *Prior to entering the Unit V process area you must complete the Vinyl/Benzene hazard communications.*
 - *No items shall be put in your mouth in the process, labs or shop areas.*
 - *Fire resistant clothing is required in designated areas around Unit's V's direct fire equipment.*
 - *Unit V's safety showers are equipped with orange drop switches which alarm in the control center. The drop switch must be activated when using the safety shower.*
 - *Diked areas require monogoggles to be worn.*
 - *Vehicles may enter the process area on a must need basis only with authorization from an area technician.*
-

**Unit Emergency
Procedures**

An area/block plot plan is shown on the back of Visitor's Card and Safe Work Permit. Also an OC-501 floor plan is available.

- *Four Assembly Points at each corner of the Unit.*
- *Entire process area contains hazardous chemicals*
- *Restroom & eating facilities are located in building OC-501*
- *There are manual Pull Switches for the Building Fire Alarm located throughout each building.*

In the event of an emergency, while working in Unit V, the following procedure should be initiated.

- **Reporting an Emergency:**
If you are involved in or observe a spill, incident, or other type of potential emergency event you must notify the control center by intercom or phone (7980/233-4023). If danger is imminent you should report condition to Industrial Security, x-66666 and notify the control center.
-

OCS Unit V
Basic Safety Orientation

Unit Emergency
Procedures
(continued)

- **Assembling & Evacuating:**
When the block unit emergency horn is sounded all safe work permits are cancelled and you must immediately report to:
 - **Alert:** *OC-501 Conference Room (160 A/B) unless otherwise directed. A decision will be made on further action.*
 - **Gas Release or Evacuate:** *Procede across and upwind to appropriate assembly point.*
 - **Building Fire Alarm:** *Immediately exit the building and go to the OC-501 Parking Lot. A decision will be made on further action.*
-

Hazard
Communication

Unit V believes that it is very important that you are aware that the following chemicals are located in the Unit and that you understand and respect the potential significant health threat each chemical poses if handled incorrectly.

VINYL CHLORIDE (VCM): Is an OSHA regulated chemical. Brief exposures to high concentrations of Vinyl Chloride may result in central nervous system depression, tiredness, and even death. Vinyl Chloride has poor warning properties, as the odor threshold is quite high.

Long term chronic exposures may result in lung, liver, and kidney effects and can also cause changes in the skin, bone, and blood circulation. Vinyl Chloride is a human carcinogen, linked to angiosarcoma, a cancer of the liver.

A medical surveillance program has been instituted for Vinyl Chloride to look for early signs of Vinyl Chloride exposure. Details of this program are located in the OSHA Standard or can be obtained through the Occupational Health Department.

The Permissible Exposure Level (PEL) is 1 ppm as an eight hour time weighted average. Jobs or tasks which require protective equipment, including respirators, will have job procedures outlining any necessary protective steps.

Contact with liquid Vinyl Chloride may cause frostbite.

BENZENE: Is an OSHA regulated chemical.

Some of Unit V's process streams contain Benzene. This chemical is listed as a carcinogen.

OCS Unit V
Basic Safety Orientation

Hazard
Communication
(continued)

ETHYLENE DICHLORIDE (EDC):

This chemical is listed as a potential carcinogen. Excessive inhalation exposure may cause nausea and/or vomiting.

METHYLENE CHLORIDE:

This chemical is listed as a potential carcinogen. Inhalation may cause irritation, sleepiness, dizziness. Contact with the skin may cause a burning sensation, numbness, irritation, possible burn.

CARBON TETRACHLORIDE:

This chemical is listed as a potential carcinogen. Inhalation may cause irritation of eyes, nose & throat, tiredness, dizziness. Alcohol consumption may increase effects.

HYDROGEN CHLORIDE (HCL):

Inhalation may cause severe irritation and injury to nose, throat, and lungs. Liquid contact may cause severe skin burns.

CELL EFFLUENT (CAUSTIC):

May cause severe injury to eyes if exposure is prolonged. If unattended, may cause severe burns to the skin.

CHLORINE:

Inhalation may cause severe irritation of nose, throat and lungs. Short single exposure may cause severe skin burns.

The Unit V material safety data sheets (MSDSs) are available to you and are located in control center. Our Industrial Hygiene Manual is located in the control center as well.

Personal
Protective
Equipment

Minimum Safety Equipment which must be worn includes:

- *Hard Hat*
 - *Side Shield Safety Glasses*
 - *Mouthbit respirator (Acid/gas)*
 - *Monogoggles carried on person when in a process area.*
-

OCS Unit V
Basic Safety Orientation

Unit Facilities

As illustrated on the OC-501 plot plan, the following are available to you:

- *The rest rooms are located in the OC-501 building.*
- *Eating facilities are located in the OC-501 building.*
- *~~Designated smoking area is located north of OC-502.~~*
- *Telephones are available for emergency use in every building except the motor control center.*
- *In case of family emergencies you can be contacted via the Control Center at 233-4023.*

Lockout/Tagout

Unit V abides by the U.S. Area Safety Standard No. 3 Lockout / Tagout. It is a requirement that before working under this system you have User training and have passed the proficiency test.

Specific LO/TO procedures relevant to this Unit only will be reviewed prior to beginning work on that job.

Safe Work Permits

Safe Work Permits can be obtained from the Process Technicians in the permit room adjacent to the control center.

The Safe Work Permits will be posted in the permit room and should be returned there when the job is complete.

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HUMAN HEALTH

Vinyl chloride is a colourless flammable gas at room temperature and pressure, with a pleasant, sweet odour at high concentrations. Human exposure to this synthetic compound is generally by inhalation and less frequently by skin absorption. Until very recently, its documented health effects were confined to Raynaud's syndrome-type symptoms (a syndrome characterized by deadening of sensations at the fingertips, whitening of fingers, and pain and sores on the hands), skin changes, bone lesions, acroosteolysis (deprivation or removal of calcium from bones in hands or feet), central nervous system depression, and disorders of the circulatory system (SOEHS 1975; EPA 1975; ICF 1974).

In 1971, a link was drawn between the inhalation of vinyl chloride monomer and malignant changes in rats. Later animal studies have further confirmed first reported cases. Subsequently, hepatic angiosarcoma (a rare form of liver cancer) cases among occupationally exposed workers were reported (SCC 1981; NTIS 1981).

In 1976, there were 48 known cases of vinyl chloride-related hepatic angiosarcomas in the world, 47 of which involved the handling of large quantities of pressurized vinyl chloride under pressure (SCC 1981). After detailed research and study, vinyl chloride is generally considered to be a confirmed human carcinogen (Doc. TLV 1981; USDHEW 1981; Doniger 1978; Senate 1974); as a result, its use has been restricted under environmental, drug, public health and regulatory laws.

Due to the tremendous usage of the chemical, its deleterious effects have been widely studied and documented. A number of agencies have reviewed vinyl chloride toxicology (VCT 1980; SCC 1976, 1981). Several reports have dealt with its carcinogenic, mutagenic and teratogenic effects. The compound is listed by the U.S. Environmental Protection Agency under the TSCA Inventory. Due to the large volume and repetitive conclusions of these tests, only the most recent or more significant of these have been documented.

The toxicological data summarized here have been extracted from reliable standard reference sources. It should be noted that some of the data are for chronic (long-term), low-level exposures and may not be directly applicable to spill situations.

7.1 Recommended Exposure Limits

The exposure standards for vinyl chloride are based upon its carcinogenic properties. Canadian provincial guidelines generally are similar to those of the USA-ACGIH unless indicated otherwise.

Guideline (Time)	Origin	Recommended Level	Reference
<u>Time-weighted Averages (TWA)</u>			
TLV (8 h)	USA-ACGIH	5 ppm (10 mg/m ³)	TLV 1983
PEL (8 h)	USA-OSHA	1 ppm	NIOSH/OSHA 1981
Action Level	USA-OSHA	0.5 ppm	GE 1978
Recommended Exposure Level	USA-NIOSH	1 ppm	NIOSH Standard 1974
Time Weighted Average Exposure	Ontario	2 ppm (5.2 mg/m ³)	Ont. Reg. 1982
Permissible Concentration (8 h)	B.C.	1 ppm, carcinogen	B.C. 1980
Concentration moyenne (8 h)	Québec	1 ppm, cancérigène	Québec 1979
Carcinogenic Substance (duration unspecified)	Saskatchewan	None given, carcinogenic substance	Saskatchewan 1981
<u>Short-term Exposure Limits (STEL)</u>			
Ceiling (15 min sample)	USA-OSHA	5 ppm	NIOSH/OSHA 1981
Ceiling (15 min sample)	USA-NIOSH	Minimum detectable - 1 ppm	NIOSH/OSHA 1981
Concentration maximale (15 min)	Québec	1 ppm, cancérigène	Québec 1979
Maximum	Ontario	10 ppm (26 mg/m ³)	Ont. Reg. 1982
<u>Other Human Toxicities</u>			
IDLH		No data	
TC _{LO} (intermittent)		500 ppm	RTECS 1979

Inhalation Toxicity Index

The Inhalation Toxicity Index (ITI) is a measure of the potential of a substance to cause injury by inhalation. It is calculated as follows:

$$ITI = 1315.12 \text{ (Vapour pressure, in mm Hg/TLV}^\circ\text{, in ppm)}$$

$$\text{At } 20^\circ\text{C, } ITI = 1315.12 \text{ (2524 mm Hg/5 ppm)}$$

$$= 6.6 \times 10^5$$

7.2 Irritation Data

7.2.1 Skin Contact.

Exposure Level (and Duration)	Effects	Reference
SPECIES: Human		
Unspecified	Sclerotic changes of the skin and various lesions.	TDB (on-line) 1981
Unspecified	Allergic dermatitis.	TDB (on-line) 1981
Unspecified	Degenerative skin changes which histologically showed destruction of the elastic network of the connective tissue (hands, forearm, face).	SOEHS 1975

7.2.2 Eye Contact.

Exposure Level (and Duration)	Effects	Reference
SPECIES: Human		
Unspecified (liquid)	Inflammation of conjunctivas and lesions in the cornea due to inflammation.	Lefèvre 1980
Unspecified (liquid)	Contact of eyes with escaping compressed vinyl chloride can produce frostbite.	Doc. TLV 1981

7.3 Threshold Perception Properties

7.3.1 Odour.

Characteristics: Mild, sweet, pleasant (Verschuieren 1984)

Odour Index: 100 (20°C) (Verschuieren 1984)

Parameter	Media	Concentration	Reference
Threshold Odour Concentration	In air	4000 to 25 000 ppm	Verschueren 1984
Detection Threshold	In air	1200 to 2000 ppm	AWQC 1978

7.3.2 Taste. No data.

7.4 Toxicity Studies

7.4.1 Inhalation.

Exposure Level (and Duration)	Effects	Reference
<u>Acute Exposures</u>		
SPECIES: Human		
25 000 ppm (3 min)	Dizziness and disorientation.	TDB (on-line) 1981
8000 to 12 000 ppm (5 min)	Intoxication signs are manifested.	ICF 1974
10 000 ppm	Noticeable anesthetic effects.	Patty 1981
4000 ppm (5 min or more)	Dizziness and confusion. Higher concentrations may lead to unconsciousness and death.	SCC 1981
1000 ppm	Slight anesthesia, drowsiness, slight visual disturbances, faltering gait, numbness and tingling of extremities.	TDB (on-line) 1981
500 ppm	TCLO	DPIMR 1981
Unspecified	After "massive" and apparently repeated exposures: euphoria followed by a state of inebriation similar to that of alcohol intoxication, epigastric pain and anorexia.	TDB (on-line) 1981
Unspecified	Two deaths reported from accidental acute VC poisoning. Cyanosis, local burns, congestion of lungs and kidneys, and failure of the blood to clot were noted.	SCC 1981

Exposure Level (and Duration)	Effects	Reference
SPECIES: Dog		
170 000 ppm (1 min)	Narcosis	EPA Assess. 1975
100 000 ppm (4 h)	Cardia arrhythmia	EPA Assess. 1975
SPECIES: Mice		
86 000 to 123 000 ppm (1 min)	Narcosis	EPA Assess. 1975
SPECIES: Guinea Pig		
200 000 ppm (18 min)	Death	INRS 1975
20 000 ppm (30 min)	TC _{LO}	DPIMR 1981
5000 ppm (30-60 min)	Pulmonary edema, hyperemia of kidneys and lungs.	INRS 1975
SPECIES: Rat		
6000 ppm (4 h)	TC _{LO}	DPIMR 1981
<u>Chronic Exposures</u>		
SPECIES: Human		
Unspecified	In 168 workers, the incidence of Raynaud's syndrome was reported as 6 percent and the incidence of liver enlargement as 30 percent.	TDB (on-line) 1981
Unspecified	Several studies of workers exposed to VCM showed various degrees of liver damage (usually enlarged liver) and enlarged spleens.	EPA Assess. 1975
Unspecified	Clinical examination of exposed workers in Dundee Research Project - deficient circulation in the extremities (Raynaud's Phenomenon); osteolysis of terminal phalanges of the fingers and to a lesser extent of the toes; degenerative skin changes with destruction of the elastic network of the connective tissue;	SOEHS 1975

Exposure Level (and Duration)	Effects	Reference
Unspecified	paresthesia of the fingers with thickening of the end segments; general symptoms of fatigue, breathlessness on exertion, dizziness, increased sweating, and pains in the upper epigastric region. Three thousand workers employed in the PVC manufacturing industry were examined. Acroosteolysis with or without Raynaud's syndrome was found in 31 of these.	SOEHS 1975
Unspecified (mean 7 yr, 2 yr and 18 yr)	Thirteen autoclave workers, mean age 39, showed first symptoms from 1-1/2 to 3-1/2 years after exposure began. Found Raynaud's syndrome, clubbing and shortening of the fingers, skin changes resembling scleroderma, with disorders of the circulatory system being the most common symptom. Laboratory tests showed reduced liver function in 11 of the workers.	SOEHS 1975
Unspecified	Thirteen PVC workers showed similar symptoms to those listed above. Two of the men who had been removed from exposure, one for 6 months and one for 1-1/2 year, subsequently developed signs and symptoms of VCM disease in hands and feet.	SOEHS 1975
Unspecified	After repeated chronic exposures, the main neurological symptoms were headaches, irritability, dizziness, sleep disorders, diaphoresis, memory loss, general asthenia and paresthesia.	SCC 1981

7.4.2 Ingestion.

Exposure Level (and Duration)	Effects	Reference
SPECIES: Rat		
500 mg/kg	LD ₅₀	RTECS 1979

7.4.3 Carcinogenicity.

Exposure Level (and Duration)	Effects	Reference
SPECIES: Human		
500 ppm (4 yr, intermittent)	TC _{LO} , carcinogen.	RTECS 1979
200 ppm (15 yr, intermittent)	Inhalation - equivocal tumorigenic agent.	RTECS 1979
Unspecified	Report of four deaths at B.F. Goodrich Chemical Company caused by the rare angiosarcoma of the liver. On investigation, NIOSH concluded vinyl chloride was a probable occupational carcinogen.	NIOSH Standard 1974
Unspecified	As of March 1976, there were 48 known cases of vinyl chloride related liver angiosarcomas, 45 of which had resulted in death. All 9 of the Canadian cases worked in one plant in Shawinigan, Québec, and 9 of the U.S. cases worked in one plant. These deaths had occurred over a period of 14 years, with the number per year showing an increase with time.	SCC 1981
Unspecified	A study of former Monsanto Company chemical plant employees has shown an increased incidence of cancer among workers	COHSN 1982

Exposure Level (and Duration)	Effects	Reference
Unspecified	exposed to vinyl chloride; 34 of 110 deaths were from cancers: lung, mouth, digestive system and lymph glands. One death was due to liver cancer. Only worksites where there had been exposure to vinyl chloride and polyvinyl chloride were examined. In addition to liver angiosarcomas, lung cancer has been found in some epidemiological studies.	Lilis 1981; Apfeldorf 1981
Unspecified	A study of VCM and PVC processing works revealed that in the VCM cohort there were significantly elevated mortality rates due to malignancy of the lymphatic gland and hematopoietic tissues and the gastrointestinal tract, the latter primarily due to tumours of the liver.	Weber 1981
1-10 ppm (long-term)	The long-term effects such as angiosarcoma, liver damage, Raynaud's syndrome may be due to levels as low as 1-10 ppm; onset of angiosarcoma is estimated to be 13-20 years; however, a few rare cases of shorter times (3-6 yr) were found.	EPA Assess. 1975
1 ppm (5 h/day, 5 d/wk, 35 yr)	A study of epidemiological results and various statistical models places the risk of liver angiosarcoma at 1.5×10^{-8} (5 out of a million) at this dosage.	Gehring 1979
SPECIES: Rat		
50 000 ppm-h	Carcinogenic dose calculated from various concentrations and times including single doses.	Hehir 1981

Exposure Level (and Duration)	Effects	Reference
6000 ppm (4 h/d 12 to 18 of pregnancy)	TC _{LO} , carcinogenic effect (inhalation).	RTECS 1979
600 ppm (8 h/d, 5 d/wk)	Angioscarcoma in 23 percent of animals; this was increased to 50 percent by administration of ethanol in water (5 percent by volume). It was concluded that ethanol is a co-carcinogen in relation to vinyl chloride.	Radike 1981
250 ppm (39 wk)	Toxic dose, carcinogenic effect (inhalation).	RTECS 1979
250 ppm (35 wk)	Toxic concentration, carcinogenic effect (inhalation).	RTECS 1979
50 ppm (30 wk)	TC _{LO} , carcinogenic effect (inhalation).	RTECS 1979
34 g/kg (2 yr)	Toxic concentration, carcinogenic effect (oral).	RTECS 1979
g/kg (3 yr)	TD _{LO} , carcinogenic effect (oral).	RTECS 1979
250, 500, 2500, 6000, 10 000 ppm (127 wk)	Induction of angiosarcoma in the liver and other organs, and other cancers. The percentage of animals having liver angio- sarcomas varied but was around 10 percent; 50 ppm exposure resulted in no angiosarcomas.	Maltoni 1974. IN NIOSH Standard 1974; ICF 1974
SPECIES: Hamster		
500 ppm (4 h/d or 30 wk)	TC _{LO} , carcinogenic effects (inhalation).	RTECS 1979
SPECIES: Mouse		
5000 ppm-h	Carcinogenic dose for mice determined by a variety of exposure periods and concen- trations.	Hehir 1981
2500 ppm (5 h/d for 26 wk, intermittently)	Toxic dose, neoplastic effects (inhalation).	RTECS 1979

Exposure Level (and Duration)	Effects	Reference
250 ppm (35 wk, intermittently)	Toxic concentration, carcinogenic effects (inhalation).	RTECS 1979
50 ppm (30 wk, intermittently)	TC _{LO} , carcinogenic effects (inhalation).	RTECS 1979
50 ppm (6 h/d for 12 wk, intermittently)	Toxic dose (inhalation).	RTECS 1979
SPECIES: Animal, unspecified		
25 ppm (4 h/d for 1 yr)	5 liver angiosarcomas, 4 zymbal gland carcinomas and 1 nephroblastoma in 120 test animals.	Patty 1981
SPECIES: Rats, Mice, Hamsters		
0-30 000 ppm (various exposures from single to 52 wk) (inhalation) 0.03 to 50 mg/kg (single dose to 5/wk for 52 wk) (ingestion or injection)	A major study involving 7000 animals of various species, strains, and sexes was conducted. The results indicate that vinyl chloride is a multi-potential carcinogen affecting a variety of organs and tissues. Liver angiosarcoma was detected in all species; many types of tumours were found. Vinyl chloride shows carcinogenic effects whether it was administered by inhalation or ingestion and shows a clear dose-response relationship. Newborn animals are the most sensitive. Vinyl chloride shows carcinogenic effects even down to 50 ppm.	Maltoni 1981
10 ppm (4 h/d for 1 yr)	1 liver angiosarcoma, 2 extra-hepatic angiosarcomas and 2 zymbal gland sarcomas in 120 test animals.	Patty 1981
1 mg/kg	3 liver angiosarcomas, 1 extra-hepatic angiosarcoma and 1 hepatoma in 150 animals.	Patty 1981

4.4 Teratogenicity and Mutagenicity.

Exposure Level (and Duration)	Effects	Reference
SPECIES: Human		
Unspecified	Increased frequency of chromosomal aberrations in lymphocytes of exposed workers.	NIOSH/OSHA Bulletin 1978
Unspecified	Increased fetal wastage among wives of male workers who have had occupational exposure to vinyl chloride.	NIOSH/OSHA Bulletin 1978; Hatch 1981
Unspecified	An epidemiological study was made of an area where the general population was exposed to VCM. The population was shown to have an excess of birth defects compared to other communities; the fluctuation in defects corresponded with VCM fluctuations in the environment.	Laval 1981
Unspecified	An epidemiological study of workers in a plastic/rubber plant revealed a greater percentage of chromosomal breakage compared to workers in other industries; however, the breakage did not correlate to VCM exposure and thus another agent(s) is suspected.	Heath 1977
SPECIES: Rat		
1500 ppm (during the first, second or third trimester of pregnancy)	Increased fetal mortality and other fetotoxic effects when administered during the first trimester; no embryotoxicity was noted when vinyl chloride was administered during the second or third trimester.	Patty 1981
SPECIES: Chinese Hamster		
00 or 5000 ppm (4 h/d for 5 d)	Chromosomal changes in bone marrow cells.	Patty 1981

Exposure Level (and Duration)	Effects	Reference
SPECIES: Hamster		
600 mg/kg	Cytogenic analysis assaying for chromosomal aberrations following administration of vinyl chloride (<u>in vivo</u>). No results reported.	RTECS 1979
20 pph (5 h)	Hamster lung cells were tested using microsomal mutagenic assay. No results reported.	RTECS 1979
SPECIES: Mouse		
3000, 10 000 or 30 000 ppm for 5 d	No dominant lethal effects.	Patty 1981
SPECIES: <i>Drosophila melanogaster</i>		
1 pph	Sex chromosome loss and non-disjunction tests have been performed (<u>in vivo</u>). Route of administration was by inhalation.	RTECS 1979
SPECIES: <i>Salmonella typhimurium</i>		
11 percent (in air)	Positive Ames test - concluded that vinyl chloride induced point mutagens but only after metabolic conversion.	Senate 1974
2 to 20 percent (in air)	Positive Ames test results by several investigators.	Fabricant 1981

7.5 Symptoms of Exposure

General symptoms of exposure found in most information sources have not been specifically referenced. Only those of a more specified or unusual nature have their sources indicated.

7.5.1 Inhalation.

1. Irritation of nose and throat.
2. Headache.

3. Overexcitement (TDB (on-line) 1981).
- . Anesthetic effects (Patty 1981).
5. Narcosis.
6. Numbness and tingling of extremities (TDB (on-line) 1981).
7. Visual disturbances (TDB (on-line) 1981).
8. Dizziness and disorientation.
9. Inebriation.
10. Faltering gait.
11. Euphoria.
12. Epigastric pain (TDB (on-line) 1981).
13. Anorexia.
14. State of shock (Lefèvre 1980).
15. Loss of consciousness.
16. Coma.
17. Death as a result of cardiac or respiratory failure (Lefèvre 1980).

7.5.2 Ingestion.

Ingestion is unlikely; however, if ingested, vinyl chloride would be toxic and cause tissue damage (AAR 1981).

7.5.3 Skin Contact.

1. Dry skin.
2. Allergic dermatitis (TDB (on-line) 1981).
3. Frostbite.
4. Irritation and burns from absorption of phenol stabilizer (GE 1978).
5. Various lesions.

7.5.4 Eye Contact.

1. Irritation.
2. Inflammation of conjunctiva.
3. Corneal lesions due to inflammation (Lefèvre 1980).

7.6 Human Toxicity to Decay or Combustion Products

Polyvinyl chloride breaks down into hydrogen chloride and carbon dioxide when subjected to excessive heat or pressure. Extensive studies have shown that phosgene has not been detected under any practical circumstances (SCC 1976), although some sources

report this product (GE 1979). Similar decomposition products might be expected when vinyl chloride burns.

7.6.1 Carbon Dioxide and Hydrogen Chloride. Carbon dioxide is a colourless, odourless gas which in elevated concentrations may act to produce mild narcotic effects, respiratory stimulation and asphyxiation. Its TLV* is 5000 ppm (8 h - TWA) and 15 000 ppm (STEL) (TLV 1983).

Hydrogen chloride may be present as a gas or a liquid. In contact with human skin it causes irritation, inflammation, burns, blistering dermatitis and profound tissue damage, depending upon concentration and length of contact. In contact with eyes it can cause stinging, burning, opaqueness of the cornea and corneal necrosis. Inhalation causes coughing, choking, ulceration of the mucosa, bronchitis, pneumonia and, in cases of exposures to extremely high concentrations, pulmonary edema and death. The TLV is 5 ppm (8 h - TWA) (TLV 1983).