

APPENDICES

Physical and Chemical Properties, Toxicity and Other Characteristics of Chemical Agents and the like

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Note 1: Lewisite, Diphenylcyanoarsine and Diphenylchloroarsine are compounds containing arsenic, and as “Arsenic and its compounds” subject to ACGIH, the Toxic and Hazardous Substances Control Acts and the Water Pollution Prevention Laws listed in the line of “Regulation/Standard” of the Tables. (ref: the table for arsenic and the like) However, these substances are special compounds for chemical weapons, so that descriptions in the line of “Regulation/Standard” are omitted.

Note 2: The figures in the unit of (mg/m³) are shown in the converted unit of ppm in parentheses. Also, any data not designated by specific temperatures are those converted at 20 .

The abbreviations in the Tables are as follows;

ACGIH:	American Conference of Government Industrial Hygienists
IARC:	International Agency for Research on Cancer
ICSC:	International Chemical Safety Cards
ICt ₅₀ :	Incapable Concentration Time 50 Percent
LCt ₅₀ :	Lethal Concentration Time 50 Percent
LD ₅₀ :	Lethal Dose 50 Percent
LCLo:	Lethal Concentration Lowest
LDLo:	Lethal Dose Lowest
TCLo:	Toxic Concentration Lowest
TDLo:	Toxic Dose Lowest
TWA:	Time-Weighted Average

Agent	Mustard (HD)		
Chemical Formula	(C ₂ H ₄ Cl) ₂ S	Molecular Weight	159.08
Melting Point (° C)	14.45	Boiling Point (°)	217*
Physical State	State: Oily liquid Odor: Garlic-like Color: Yellow ~dark brown (in case of pure substance, colorless and odorless)		
Volatility	0 : 75mg/m ³ (11ppm) 20 : 610mg/m ³ (92ppm) 40 : 2,860mg/m ³ (462ppm)		
Vapor Pressure	0.072mmHg (20°)		
Solubility (g/L)	0.8** (20°)		
Hydrolysis Speed	In distilled water (25°): 50% soluble in 8.5 min. In sea water (25°): 50% soluble in 60 min.		
Toxicity Index	50 % Lethal Density (LC ₅₀)	Human (inhalation): 1,500mg-min/m ³ (230ppm-min) Human (through skin): 10,000mg-min/m ³ (0.15%-min)	
	50% Incapable Density (IC ₅₀)	Human (eye): 200mg-min/m ³ (30ppm-min) Human (through skin): 2,000mg-min/m ³ (310ppm-min) (21 ~27°) 1,000mg-min/m ³ (160ppm-min) (32°)	
	50% Lethal Dose (LD ₅₀)	Human (through skin): 100mg/kg*** Human (oral dose): 0.7mg/kg***	
	Category for Cancer-Causing (IARC)	Group 1 (Carcinogenic to humans)	
	Detoxification/Others	Detoxification is very slow. Even small dosages, if repeatedly exposed, accumulate effects of blister agents.	
Symptoms	Initial damage takes place on a cellular level, progressing to surface damage of all the tissues exposed to the agent. The initial symptoms normally appear in 4 to 6 hours. The higher the density, the faster the symptoms appear. Local physiological symptoms: Eye's conjunctivitis or inflammation, reddening as the initial symptom for developing blistering and ulcer, and inflammations of nose, throat, respiratory tract and lung. Total physiological symptoms: Along with skin reddening, nausea, vomiting and fever develop. In case of exposure to lethal dosage, damages develop in the marrow, lymph node and spleen.		
Regulation/Standard	The US Army's standards: Permissible exposure limit of airborne contamination for workers (8hours exposure) : 0.003mg/m ³ (0.00045ppm) Permissible emission limit of hazardous air pollutants: 0.03mg/m ³ (0.0045ppm)		
Remarks	Stable at room temperatures. Decomposes at temperatures between 149 ~177° . Mustard is hard to decompose, depending on pH and humidity, and is known to have been active underground for three years.		

Notes:

Sources are mainly "Military Chemistry and Chemical Compounds, FM3-9 (1975, 10)"

* Decomposed at 149° (177°)

** Source: "The Challenge of Old Chemical Munitions and Toxic Armament Wastes" Stockholm International Research Institute (1997)

*** Source: "US Army Material Safety Data Sheets (1997)"

Agent	Lewisite (L)		
Chemical Formula	$\text{CHCl}=\text{CHAsCl}_2$	Molecular Weight	207.35
Melting Point ()	-18 ~0.1	Boiling Point ()	190*
Physical State	State: Liquid Odor: Normally western hollyhock-like Color: Amber ~dark brown (in case of pure substance, colorless and almost odorless)		
Volatility	0 : 1,060mg/m ³ (115ppm) 20 : 4,480mg/m ³ (519ppm) 30 : 8,620mg/m ³ (1,030ppm)		
Vapor Pressure	0.087mmHg (0), 0.394mmHg (20)		
Solubility (g/L)	0.5**		
Hydrolysis Speed	Fast in case of vapor or melted Lewisite. As solubility is low in water, hydrolysis is limited.		
Toxicity Index	50 % Lethal Density (LC _{t50})	Human (inhalation): 1,200 ~ 1,500mg-min/m ³ (140 ~ 170ppm-min) Human (through skin in case of wearing protection mask): 100,000mg-min/m ³ (1.2%-min)	
	50% Incapable Density (IC _{t50})	Human (eye): Less than 300mg-min/m ³ (35ppm-min) Human (through skin in case of wearing protection mask): Less than 1,500mg-min/m ³ (170ppm-min)	
	50% Lethal Dose (LD ₅₀)	Rat (oral dose): 50mg/kg*** Rabbit (through skin): 6mg/kg***	
	Category for Cancer-Causing (IARC)	Carcinogenicity is suspected***	
	Detoxification/Others	Organism does not detoxify Lewisite.	
Symptoms	The symptoms are similar to those of Mustard. In addition exposure causes pulmonary edema, diarrhea, restlessness, weakness, subnormal temperature and low blood pressure. Exposure of eye to liquid Lewisite immediately causes a burning sensation followed by permanent loss of vision, unless decontaminated with a large quantity of water within one minute of exposure. Contact with skin produces immediate stinging followed by skin reddening within 30 minutes of exposure. Blisters do not appear until 13 hours after exposure. Skin burns are much deeper than with Mustard. Inhalation of high concentration of Lewisite may cause death within ten minutes.		
Regulation/Standard	The US Army's standards: Permissible exposure limit of airborne contamination for workers (8hours exposure) : 0.003mg/m ³ (0.00035ppm) Permissible emission limit of hazardous air pollutants: 0.03mg/m ³ (0.0035ppm)		
Remarks			

Notes:

Sources are mainly "Military Chemistry and Chemical Compounds, FM-9 (1975, 10)"

* The melting point of Lewisite varies with the purity.

** Source: "The Challenge of Old Chemical Munitions and Toxic Armament Wastes" Stockholm International Research Institute (1997)

*** Source: "US Army Material Safety Data Sheets (1997)"

Agent	Diphenylcyanoarsine (DC)		
Chemical Formula	(C ₆ H ₅) ₂ AsCN	Molecular Weight	255.0
Melting Point ()	31.5 ~ 35	Boiling Point ()	Decomposed at 350
Physical State	State: Solid Odor: Similar to a mixture of garlic and almond		
Volatility	20 : 2.8mg/m ³ (0.26ppm)		
Vapor Pressure	0.0002mmHg (20)		
Solubility (g/L)	2*		
Hydrolysis Speed	Very slow		
Toxicity Index	50 % Lethal Density (LC _{t50})	Human: 10,000mg-min/m ³ (940ppm-min)	
	50% Incapable Density (IC _{t50})	Human, 30sec. exposure: 30mg-min/m ³ (2.8ppm-min) Human, 5min. exposure: 20mg-min/m ³ (1.9ppm-min)	
	50% Lethal Dose (LD ₅₀)		
	Category for Cancer-Causing (IARC)		
	Detoxification/Others	One hour after incapacitated, the effect dies away.	
Symptoms	The symptoms progress with stinging in eyes and mucous membranes, along with nasal secretions similar to those of a cold. Sneezing, coughing, severe headache, sharp chest pain, oppressive feeling and vomiting are also exhibited. Toxicity of DC is stronger than that of DA. In the event of mild concentration, the effects last for 30 minutes after escaping the contaminated environment. In the event of higher concentration, the effects last for several hours.		
Regulation/Standard			
Remarks	The effect is extremely rapid. 25% decomposed at temperatures at 300 . Most of the agent is decomposed due to explosion for spreading.		

Notes:

Sources are mainly “Military Chemistry and Chemical Compounds, FM3-9 (1975, 10)”

* Source: “The Challenge of Old Chemical Munitions and Toxic Armament Wastes” Stockholm International Research Institute (1997)

Agent	Diphenylchloroarsine (DA)		
Chemical Formula	(C ₆ H ₅) ₂ AsCl	Molecular Weight	264.5
Melting Point ()	41~44.5	Boiling Point ()	Decomposed at 331
Physical State	State: Solid Odor: No significant odor Color: Colorless		
Volatility	45 : 48mg/m ³ (4.7ppm)		
Vapor Pressure	0.0036mmHg (45)		
Solubility (g/L)	2*		
Hydrolysis Speed	Slow in a form of lump, but fast in fragments		
Toxicity Index	50 % Lethal Density (LC ₅₀)	Human : 15,000mg-min/m ³ (1,400ppm-min) (Assumed)	
	50% Incapable Density (IC ₅₀)	Human (exposed longer than 10 min.): 12mg-min/m ³ (1.1ppm-min) Human (exposed shorter than 10 min.): Probably, higher than the above figures	
	50% Lethal Dose (LD ₅₀)		
	Category for Cancer-Causing (IARC)		
	Detoxification/Others	Even with a dosage enough for complete incapacitation, detoxified within 1~2 hours.	
Symptoms	The symptoms progress with stinging in eyes and mucous membranes, along with nasal secretions similar to those of a cold. Sneezing, coughing, severe headache, sharp chest pain, oppressive feeling and vomiting are also exhibited. In the event of mild concentration, the effects last for 30 minutes after escaping the contaminated environment. In the event of higher concentration, the effects last for several hours.		
Regulation/Standard			
Remarks	The effect is very rapid.		

Notes:

Sources are mainly "Military Chemistry and Chemical Compounds, FM3-9 (1975, 10)"

* Source: "The Challenge of Old Chemical Munitions and Toxic Armament Wastes" Stockholm International Research Institute (1997)

Agent	Phosgene (CG)		
Chemical Formula	COCl ₂	Molecular Weight	98.92
Melting Point ()	-128	Boiling Point ()	7.6
Physical State	State: Gas Odor: New hay-like or green corn-like Color: Colorless (gas), Colorless~light yellow (liquid)		
Volatility	-40 : 528,000mg/m ³ (10.2%) -10 : 2,200,000mg/m ³ (48.0%) 7.6 : 43,000,000mg/m ³ (100%)		
Vapor Pressure	365mmHg (-10), 555mmHg (0), 1,173mmHg (20)		
Solubility (g/L)	9*		
Hydrolysis Speed	Hard to dilute in water, but under a normal battle condition, the hydrolysis is rapid. Rain decreases the effect of the chemical agent. The hydrolysis produces carbon dioxide and hydrogenchloride.		
Toxicity Index	50 % Lethal Density (LC ₅₀)	Human (inhalation) : 3,200mg-min/m ³ (780ppm-min) Rat (inhalation) LC ₅₀ : 1,400mg/m ³ /30min. (340ppm/30min) Mouse (inhalation) LC ₅₀ : 1,800mg/m ³ /30min. (440ppm/30min) Guinea pig (inhalation) LC ₅₀ : 1,300mg/m ³ /30min. (320ppm/30min)	
	50% Incapable Density (IC ₅₀)	Human (inhalation): 1,600mg-min/m ³ (390ppm-min)	
	50% Lethal Dose (LD ₅₀)		
	Category for Cancer-Causing (IARC)		
	Detoxification/Others	Not detoxified but accumulating	
Symptoms	Phosgene affects the lung. Phosgene causes damage to capillary vessels and exudes water-soluble secretion into the lungs, resulting in severe lung damage. With the lungs flooded with secretion and no air space, the contaminated person suffocates to death. In case of contamination with less dose than the lethal dose of phosgene and with proper medical treatment, the secretion is absorbed back and the wall cells of lungs are revitalized, and the contaminated person will recover. The effect of phosgene does not appear until 3 to 4 hours have passed after contamination. Thus, it is impossible to predict the degree of contamination from the immediate symptoms. Most of deaths take place within 24 hours.		
Regulation/Standard	The Labor Safety and Hygiene Law: The third category of special chemical substances ** The Air Pollution Control Law: Special substances ACGIH: TWA 0.1ppm, 0.40mg/ m ³		
Remarks	Widely used during the World War I, and more than 80% of the deaths due to chemical weapons during the War are assumed attributed to phosgene. Heated phosgene produces toxic gas (chlorine, carbon monoxide)		

Notes:

Sources are mainly "Military Chemistry and Chemical Compounds, FM3-9 (1975, 10)"

* Source: "The Challenge of Old Chemical Munitions and Toxic Armament Wastes" Stockholm International Research Institute (1997)

** Handbook of Dangerous Materials (Springer-Verlag Tokyo)

Agent	Trichloroarsine		
Chemical Formula	AsCl ₃	Molecular Weight	181.28
Melting Point ()	-16	Boiling Point ()	130
Physical State	State: Oily non-flammable liquid Odor: Sharp stinging Color: Colorless		
Volatility			
Vapor Pressure	1.17kPa (8.78mmHg) (20)		
Solubility (g/L)	Reacted with water forming to hydrochloric acid and arsenious acid		
Hydrolysis Speed	Refer to the above		
Toxicity Index	50 % Lethal Density (LC ₅₀)	Mouse (inhalation) LCLo: 338ppm/10min. Cat (inhalation) LCLo: 200mg/m ³ /20min. (27ppm/20min.)	
	50% Incapable Density (IC ₅₀)		
	50% Lethal Dose (LD ₅₀)		
	Category for Cancer-Causing (IARC)	Group 1 (Carcinogenic to humans: As arsenic and its compounds)	
	Detoxification/Others		
Symptoms*	<p>Effects of short period exposures:</p> <ul style="list-style-type: none"> - Lesioning of eyes, skin and respiratory tracts - Inhalation of the vapor may causes pulmonary edema - Effecting on cardiac blood system, central nervous system and gastrointestinal tracts, the exposure causes adverse health effects such as severe hemorrhage, loss of body fluids, loss of electrolytes, and shock, eventually resulting in death according to circumstances - The exposures may result in death <p>Effects of extended or repeated exposures:</p> <ul style="list-style-type: none"> - Effecting on mucous membranes, skin, kidneys, livers and peripheral nerve system, the exposures may cause neurological disorders, pigment cell disorder and nasal septum perforation - Carcinogenicity in humans is exhibited 		
Regulation/Standard	<p>The Toxic and Hazardous Materials Control Law: Toxic material</p> <p>The emission standard of the Water Pollution Prevention Law: Arsenic and its compounds: 0.1mg/L (As)</p> <p>ACGIH: Arsenic and its compounds : TWA 0.01mg/m³ (As)</p>		
Remarks	<p>[Notice for handling and storage]</p> <p>No contact is allowed with acid, base or oxidizing agents. Contact causes heat-decomposition, producing toxic oxidized arsenic and hydrogen chloride gas, followed by smoking in the air and strong stinging. Exposure to light causes change of the physical state. The agent should be stored in a well ventilated dark, chilly and dry place apart far from any heat sources and flammable materials.</p>		

Notes:

Sources are mainly Great Chemical Dictionary (Tokyo Chemical Society), Zack's Data Book of Hazardous Materials (Maruzen), Handbook of Dangerous Materials (Springer-Verlag Tokyo)

* Source: International Chemical Safety Cards (ICSC 1989)

Agent	Hydrogen Cyanide		
Chemical Formula	HCN	Molecular Weight	27.02
Melting Point ()	-13.3	Boiling Point ()	25.7
Physical State	State: Gas or liquid Odor: Peculiar (gas), almond-like (water solution) Color: Colorless		
Volatility	-40 : 3,700mg/m ³ (0.26%) 25 : 1,088,000mg/m ³ (98.5%)		
Vapor Pressure	742mmHg (25)		
Solubility (g/L)	Completely soluble in water, but easily vaporized		
Hydrolysis Speed	Slow in the open air		
Toxicity Index	50 % Lethal Density (LC _{t50})	Human (concentration of 200mg/ m ³): Approx. 2,000mg-min/ m ³ (0.18%-min) Human (concentration of 150mg/ m ³): Approx. 4,500mg-min/ m ³ (0.40%-min)	
	50% Incapable Density (IC _{t50})	Varies with concentration	
	50% Lethal Dose (LD ₅₀)	Mouse (oral dose): 3.7mg/kg*	
	Category for Cancer-Causing (IARC)		
	Detoxification/Others	Fast. 0.017mg/kg/min	
Symptoms	<p>Hydrogen cyanide prevents oxygen supply by damaging cytochrome oxidase enzymes.</p> <p>In case of exposure to low concentration: Headache, breathing difficulty, vomiting and unconsciousness occur gradually*</p> <p>In case of exposure to high concentration: Rapidly falling into unconsciousness and a deep coma, followed by breathing difficulty, low blood pressure, restraint reactions and dilation of pupils, resulting in death*</p>		
Regulation/Standard	<p>The Toxic and Hazardous Materials Control Law: Toxic material</p> <p>The Labor Safety and Hygiene Law: The second category of special chemical substances</p> <p>The High Pressure Gas Safety Law: Liquid hydrogen Cyanide as high pressured gas</p> <p>The Air Pollution Control Law: Special substance</p> <p>The emission standard of the Water Pollution Prevention Law: As cyanide compounds: 1mg/L (Cyanide)</p> <p>ACGIH: CEILING** 4.7ppm, 5mg/m³ (As)</p>		
Remarks	The flash point is about 17.8 , and once sprayed out of the projectile, 50% of the agent is incinerated. Except highly pure ones, the agents are generally unstable. The agents stored for a long period form explosive polymers.		

Notes:

Source is mainly "Military Chemistry and Chemical Compounds, FM3-9 (1975,10)

* Handbook of Dangerous Materials (Springer-Verlag Tokyo)

** The value that can not be exceeded under any circumstances

Agent	Sarin (GB)		
Chemical Formula	$\text{CH}_3\text{P}(\text{O})(\text{F})\text{OCH}(\text{CH}_3)_2$	Molecular Weight	140.1
Melting Point ()	-56	Boiling Point ()	158
Physical State	State: Liquid Odor: Almost odorless in case of a pure agent Color: Colorless		
Volatility	0 : 4,100mg/m ³ (660ppm) 25 : 22,000 mg/m ³ (3,800ppm) 30 : 29,800 mg/m ³ (5,300ppm)		
Vapor Pressure	2.9mmHg (25)		
Solubility (g/L)	Miscible with water		
Hydrolysis Speed	Varies with pH. With pH of 1.8, 50% is hydrolyzed in 7.5 hours. Hydrolyzed in a non-buffer solution in 30 hours, and rapidly hydrolyzed in an alkaline solution.		
Toxicity Index	50 % Lethal Density (LC ₅₀)	Human (inhalation at rest): 100mg-min/m ³ (17ppm-min) Human (inhalation at light work): 70mg-min/m ³ (12ppm-min)	
	50% Incapable Density (IC ₅₀)	Human (inhalation at rest): 75mg-min/m ³ (13ppm-min) Human (inhalation at light work): 35mg-min/m ³ (6.0ppm-min)	
	50% Lethal Dose (LD ₅₀)	Human (vein): 0.014mg/kg*	
	Category for Cancer-Causing (IARC)		
	Detoxification/Others	Detoxification is slow. Accumulating	
Symptoms	<p>Inhibition of cholinesterase, hydrolysis enzyme of acetylcholine that transmits signals between nerve cells.</p> <p>Effects on eyes: Strong toxicity. More effects by absorption through eyes than skin. The vapor causes contraction of pupils and dimness of vision in the dark.</p> <p>Effects on skin: Liquid contact does not cause skin damage but is rapidly absorbed. Any adhesion of even a tiny liquid drop of the agent should be decontaminated immediately. As well as the liquid drops, the vapor absorbs through skin. The LC₅₀ of the vapor for skin of a naked person is approximately 12,000mg-min/m³ (0.21%), and for skin of a person in combat fatigue approximately 15,000mg-min/m³ (0.26%).</p> <p>In case of a lethal dose, death normally occurs in 15 minutes.</p>		
Regulation/Standard	<p>The US Army's standards:</p> <p>Permissible exposure limit of airborne contamination for workers (8hours exposure) : 0.0001mg/m³ (1.7x10⁻⁵ppm)</p> <p>Permissible emission limit of hazardous air pollutants: 0.0003mg/m³ (5.2x10⁻⁵ppm)</p>		
Remarks	Completely decomposed in 2.5 hours at 150		

Notes:

Source is mainly "Military Chemistry and Chemical Compounds, FM3-9 (1975,10)"

* Source: The US Army Data (1974,1975)

Agent	Arsenic		
Chemical Formula	As	Molecular Weight	74.9
Melting Point ()	814 (36atm)	Boiling Point ()	613 (sublimating point)
Physical State	State: Crystal, formless semi-metal Color: Silver white~black		
Volatility			
Vapor Pressure	1mmHg (372) (sublimation)		
Solubility (g/L)	Insoluble in water		
Hydrolysis Speed			
Toxicity Index	50 % Lethal Density (LC ₅₀)		
	50% Incapable Density (IC ₅₀)		
	50% Lethal Dose (LD ₅₀)	Rat (in abdominal cavity): 13.39mg/kg Guinea pig (subcutaneous) LDLo: 300mg/kg Human, male (oral dose) TDLo: 7,857mg/kg/55years	
	Category for Cancer-Causing (IARC)	Group 1 (Carcinogenic to humans)	
	Detoxification/Others	Mineral arsenic is metabolized in liver, and part of it is transformed into low toxic methyl arsenic compounds (mainly DMA)*	
Symptoms **	Effects of short period exposures: <ul style="list-style-type: none"> - Stinging in eyes, skin and respiratory tracts - Effecting on liver, kidney and digestive canals, the exposures may cause cirrhosis and kidney damages - The exposures may result in death Effects of extended exposures: <ul style="list-style-type: none"> - May cause skin inflammations and skin diseases due to extended or repeated exposures - May effect on liver and neural system - Carcinogenicity in humans is exhibited - May cause inherent abnormality 		
Regulation/Standard	The Toxic and Hazardous Materials Control Law: Toxic material The emission standard of the Water Pollution Prevention Law: Arsenic and its compounds: 0.1mg/L (As) ACGIH: Arsenic and its compounds : TWA 0.01mg/m ³ (As)		
Remarks	[Notice for handling and storage] No contact is allowed with acid, base or oxidizing agents. Mixing with oxidation agent may cause ignition. The contact causes heat-decomposition, producing vapor of oxidized arsenic (III) which has strong hemolytic effects. The agent should be stored in a well ventilated dark, chilly and dry place apart far from any heat sources and flammable materials.		

Notes:

Sources are mainly Great Chemical Dictionary (Tokyo Chemical Society), Zack's Data Book of Hazardous Materials (Maruzen), Handbook of Dangerous Materials (Springer-Verlag Tokyo)

* Source: Report by Heavy Metal Assessment Working Group of Health Affect Assessment Review Committee, Journal of Atmospheric Environment Society No.6 of Volume 30 (1995)

** Source: International Chemical Safety Cards (ICSC 1988)

Agent	Arsenic Trioxide (Arsenic Oxide)		
Chemical Formula	As ₂ O ₃	Molecular Weight	197.8
Melting Point ()	278~280*	Boiling Point ()	460
Physical State	State: Lumpish or crystalline powder Odor: odorless even at the toxic level of density** Color: White or transparent		
Volatility	Little vaporization at 20 , but the airborne particles may rapidly reach the toxic level of density		
Vapor Pressure			
Solubility (g/L)	Slightly soluble (0.1~1%)***		
Hydrolysis Speed			
Toxicity Index	50 % Lethal Density (LCt ₅₀)	Human (oral dose) TCLo: 0.11mg/m ³ (As)****	
	50% Incapable Density (ICt ₅₀)		
	50% Lethal Dose (LD ₅₀)	Rat (oral dose): 14.6mg/kg Rat (in abdominal cavity): 871mg/kg Mouse (oral dose): 31.5mg/kg Mouse (subcutaneous): 9.8mg/kg Human (oral dose) LDLo: 1.429mg/kg	
	Category for Cancer-Causing (IARC)	Group 1 (Carcinogenic to humans : As arsenic and its compounds)	
	Detoxification/Others		
Symptoms**	<p>Effects of short period exposures:</p> <ul style="list-style-type: none"> - Lesioning eyes, skin and respiratory tracts - May effect on internal organs (kidney, liver), cardiac system, neural system, hematogenous system - The exposures may result in death <p>Effects of long period or repeated exposures:</p> <ul style="list-style-type: none"> - May effect on lung, skin, bone marrow(change of blood-forming), peripheral vein system, neural system, cardiac function, kidney and liver - Carcinogenicity in humans is exhibited - As well as other arsenic compounds, may cause inherent abnormality 		
Regulation/Standard	<p>The Toxic and Hazardous Materials Control Law: Toxic material</p> <p>The Labor Safety and Hygiene Law: The second category of special chemical substances</p> <p>The emission standard of the Water Pollution Prevention Law: Arsenic and its compounds: 0.1mg/L (As)</p> <p>ACGIH: Arsenic and its compounds : TWA 0.01mg/m³ (As)</p>		
Remarks	<p>[Notice for handling and storage]</p> <p>No contact is allowed with oxidizing agents. The contact causes heat-decomposition, producing vapor of oxidized arsenic (III) which has strong hemolytic effects. The agent should be stored in a well ventilated dark, chilly and dry place apart far from any heat sources and flammable materials.</p>		

Notes:

Sources are mainly Great Chemical Dictionary (Tokyo Chemical Society), Zack's Data Book of Hazardous Materials (Maruzen), Handbook of Dangerous Materials (Springer-Verlag Tokyo)

* Source: Sublimating points are at a range of 125~150

** "International Chemical Safety Cards (ICSC 1990)"

*** Source: "US Army Material Safety Data Sheets (1990)"

**** Source: Safety Data Sheets of Chemical Substances (Incorporated Foundation: Future Technology Institute)

Agent	Arsenic Pentoxide		
Chemical Formula	As ₂ O ₅	Molecular Weight	229.8
Melting Point ()	315	Boiling Point ()	
Physical State	State: Deliquescent lumpish or powder Odor: odorless even at the toxic level of density* Color: White		
Volatility	Little vaporization at 20 , but the airborne particles may rapidly reach the toxic level of density		
Vapor Pressure			
Solubility (g/L)	Readily soluble in water (150g/100ml, 16)		
Hydrolysis Speed			
Toxicity Index	50 % Lethal Density (LC ₅₀)		
	50% Incapable Density (IC ₅₀)		
	50% Lethal Dose (LD ₅₀)	Mouse (oral dose): 55mg/kg** Rat (oral dose): 8mg/kg** Rabbit (vein) LDLo: 6mg/kg**	
	Category for Cancer-Causing (IARC)	Group 1 (Carcinogenic in humans : As arsenic and its compounds)	
	Detoxification/Others		
Symptoms**	<p>Effects of short period exposures:</p> <ul style="list-style-type: none"> - Lesioning eyes, skin and respiratory tracts - May effect on kidney, liver, cardiac blood system, neural system and blood system - The exposures to far higher concentration than the allowable value may result in death - May exhibit the effects with a time lag <p>Effects of extended or repeated exposures:</p> <ul style="list-style-type: none"> - May effect on lung, skin, bone marrow(change of blood-forming), and other organs - Carcinogenicity in humans is exhibited - May cause reproduction toxicity in humans 		
Regulation/Standard	<p>The Toxic and Hazardous Materials Control Law: Toxic material</p> <p>The emission standard of the Water Pollution Prevention Law: Arsenic and its compounds: 0.1mg/L (As)</p> <p>ACGIH: Arsenic and its compounds : TWA 0.01mg/m³ (As)</p>		
Remarks	Decomposes at a temperature of over 300 , producing arsenic trioxide and oxygen. The solution is a mid-level strong acid. May produce toxic gas (arsine) by reacting to reduction agents. Exhibits corrosiveness to metals in a moistly atmosphere		

Notes:

Sources are mainly Great Chemical Dictionary (Tokyo Chemical Society), Zack's Data Book of Hazardous Materials (Maruzen), Handbook of Dangerous Materials (Springer-Verlag Tokyo)

* "International Chemical Safety Cards (ICSC 1991)"

** Source: Safety Data Sheets of Chemical Substances (Incorporated Foundation: Future Technology Institute)

Agent	Dioxin		
Chemical Formula	(2,3,7,8-TCDD)*	Molecular Weight	322
Melting Point ()	305~306	Boiling Point ()	Decomposed at a temp. of over 700
Physical State	State: Solid Odor: odorless** Color: Colorless**		
Volatility			
Vapor Pressure			
Solubility (g/L)	2×10^{-7} (25)		
Hydrolysis Speed			
Toxicity Index	50 % Lethal Density (LC ₅₀)		
	50% Incapable Density (IC ₅₀)		
	50% Lethal Dose (LD ₅₀)	Guinea pig (oral dose): 600ng/kg Hamster (oral dose): Approx. 5,051,000ng/kg Lethal dose widely varies in species of animals, systems and dosing routes	
	Category for Cancer-Causing (IARC)	Group 1 (Carcinogenic to humans)	
	Detoxification/Others	According to a report of a test case of a male volunteer with oral doses of TCDD (1.14ng/kg), the half-life was 2120 days. In an investigation of soldiers participated in Vietnam War, the half-life in serums is reported to be 7.1~11.3 years	
Symptoms**	<p>Tests on pregnant animals (rats and the like) revealed that the animals dosed with dioxin cause such deformities as hare lip and kidney inflammation. Furthermore, results of animal tests show that dioxin causes deterioration of thyroid gland function, degeneration of reproductive organs, reduction of sperm count and weakening of the immune system as dioxin mimics hormones in body.</p> <p>As for human, it is reported that dioxin may relate to the spinal deformations of the offspring of soldiers repatriated from Vietnam War, but there are still many unknown factors and missing evidence sufficient to prove whether there are the same effects on human as those on tested animals.</p>		
Regulation/Standard	<p>The Discharge Standards of Waste Disposal Incinerator (Japan):</p> <p>0.1ng-TEQ/Nm³ (newly installed, incinerator capacity of not less than 4 tons)</p> <p>1.0ng-TEQ/Nm³ (newly installed, incinerator capacity of 2~4 tons)</p> <p>5.0ng-TEQ/Nm³ (newly installed, incinerator capacity of less than 2 tons)</p>		
Remarks			

Notes:

Source: Interim Report by Study Group on Dioxin Risk Assessment (1996) (Ministry of Health and Welfare)

* The isomer with the strongest toxicity among the dioxin group, and the figures or data of molecular weight, melting point, boiling point, solubility and toxicity indexes in the above table refer to the data of this isomer.

** Source: Summarized of a pamphlet (1998) prepared by Environment Risk Assessment Group and Environmental Safety Dept. of Environmental Health Div. of Environment Agency