TOXIC EXPOSURE TABLE (IN REFERENCE TO VA 10-03)

This toxic exposure table will serve four main purposes; (1) It will inform veterans, benefit counselors and clinicians on specific environmental hazard incidents that present potential health risks to service members and Veterans. (2) It provides guidance on handling medical evaluations and benefit claims for disabilities potentially resulting from exposure to environmental hazards while on active duty. (3) It provides information that may serve as valuable resources for VA examiners when they conduct Compensation and Pension (C&P) examinations associated with such exposure. 4) It serves as a reference guide for members of congress serving their constituents affected by burn pit exposure.

Chemical	Target Organs/Systems	Possible Health Effects
POLYCYCLIC AROMATIC HYDROCARBONS (PAHS)		
Acenaphthene	Liver and Kidneys	Irritation of nose, throat and lungs upon inhalation. May affect liver and kidneys (1).
Anthracene	Multisystem: Skin, blood, stomach, liver, intestines, lymph	Burning, itching and edema, a buildup of fluid in tissues, headaches, nausea, loss of appetite, inflammation or swelling of the stomach and intestines (2).
Benzo(a)pyrene	Hematological, Immunological, Neurological	Mucous membrane irritation, dermatitis, bronchitis, cough, dyspnea, conjunctivitis, photosensitization, aplastic anemia, allergic reactions, keratoses, discoloration of the cornea and epithelioma lid margin in chronic exposure, pulmonary edema, reproductive effects and leukemia (9). Genotoxic effects.
Benzo(b)fluoroanthene	**Hematological, Immunological, Neurological**	Probable human carcinogen. Has shown lung, skin, and liver cancers in animal models. Skin and eye irritation (10). **Breathing benzene can cause drowsiness, dizziness, and unconsciousness; long-term benzene exposure causes effects on the bone marrow and can cause anemia and leukemia. Benzene has been found in at least 1,000 of the 1,684 National Priority List sites identified by the Environmental Protection Agency (EPA).**
Benzo(k)fluoroanthene	Hematological, Immunological, Neurological	Probable carcinogen. Eye and skin irritant (11). **Breathing benzene can cause drowsiness, dizziness, and unconsciousness; long-term benzene exposure causes effects on the bone marrow and can cause anemia and leukemia. Benzene has been found in at least 1,000 of the 1,684 National Priority List sites identified by the Environmental Protection Agency (EPA).**

Chemical	Target Organs/Systems	Possible Health Effects
Dibenz (a,h) anthracene	Hematological, Immunological, Neurological	Dizziness, vomiting, unconsciousness, cancers, and other health effects from prolonged exposures. Genotoxic in mammalian cells (3).
Fluorene	Hematological	Decreased red blood cells, packed cell volume and hemoglobin (4).
Naphthalene	Hematological, Liver, Neurological, Lungs, Eyes	Headache, nausea, vomiting, diarrhea, malaise, confusion, anemia, jaundice, convulsions coma, cataracts, retinal hemorrhage, hemolytic anemia (EPA, 5).
Pyrene	Lungs, Neurological, Renal, Liver, Bone/Marrow	Probable human carcinogen. Depending on type of exposure (IE Tar, coal, smoke, etc.) cancer of the kidneys, lungs, skin, brain, and bone (12, 13).
Acenaphthylene	Multisystem Cancer	The CDC warns to treat all these material as carcinogens. Samples and unused standard (extremely small doses) are considered Toxic Waste. Health effect is cancerous (13).
Benzo(a)anthracene	Hematological, Immunological, Neurological	Probable carcinogen. Aplastic anemia and reproductive effects seen in animal models (14). **Breathing benzene can cause drowsiness, dizziness, and unconsciousness; long-term benzene exposure causes effects on the bone marrow and can cause anemia and leukemia. Benzene has been found in at least 1,000 of the 1,684 National Priority List sites identified by the Environmental Protection Agency (EPA).**
Benzo(g,h,i)perylene	Unknown	Unknown carcinogenicity (15). Similar PAH have demonstrated carcinogenic and reproductive effects in animal models (16). **Breathing benzene can cause drowsiness, dizziness, and unconsciousness; long-term benzene exposure causes effects on the bone marrow and can cause anemia and leukemia. Benzene has been found in at least 1,000 of the 1,684 National Priority List sites identified by the Environmental Protection Agency (EPA).**
Chrysene	Immune System	Increased risk for tumor and cancer exposure (17).

Chemical	Target Organs/Systems	Possible Health Effects
Fluoranthene	Skin, Bone, Lung, Brain, Neurological, Hematological	Irritant. Contact burns, nausea, tachycardia, cardiac arrhythmias, liver injury, pulmonary edema, and respiratory arrest (18). Potential endocrine disruptor. Limited evidence of carcinogenicity (19).
Indeno(1,2,3-cd)pyrene	Multisystem Carcinogen	Increased allergic inflammation and airway eosinophilia (20). Carcinogen (21).
Phenanthrene	Unknown	Inadequate studies to determine carcinogenic properties. Currently considered a non-carcinogenic PAH, but structurally similar to carcinogenic PAHs (22). Irritant (23).
VOLATILE ORGANIC COMPOUNDS (VOC)		
Acetone	Neurological	CNS depression, dermatitis , dizziness , headache, eye irritation, nose irritation, irritation of the throat, delayed reaction times, nephropathy through oral exposure (EPA, 6).
Benzene	Immune System, Blood	Drowsiness, dizziness, rapid heart rate, headaches, tremors, confusion, and unconsciousness. Eating or drinking foods containing high levels of benzene can cause vomiting, irritation of the stomach, dizziness, sleepiness, convulsions, rapid heart rate, and death. Long-term exposure to high levels of benzene in the air can cause leukemia, particularly acute myelogenous leukemia, often referred to as AML (24). **Breathing benzene can cause drowsiness, dizziness, and unconsciousness; long-term benzene exposure causes effects on the bone marrow and can cause anemia and leukemia. Benzene has been found in at least 1,000 of the 1,684 National Priority List sites identified by the Environmental Protection Agency (EPA, 25).**
Chlorodifluoromethane	Respiratory system, Cardiovascular system, Central Nervous System, Liver, Kidneys, Spleen	Irritation respiratory system; confusion, drowsiness, ringing in ears; heart palpitations, cardiac arrhythmias; asphyxia; liver, kidney, spleen injury; liquid: frostbite (26).

Chemical	Target Organs/Systems	Possible Health Effects
Acrolein	Cardiovascular, hematological, ocular, respiratory	Irritation of upper respiratory tract and eyes, respiratory congestion, dyspnea, cyanosis, fever (27). Suppression of immune responses, may play a role in lung cancer (28, 29).
Carbon Disulfide	Central nervous system, peripheral nervous system, cardiovascular system, eyes, kidneys, liver, skin, reproductive system	Chest pain, respiratory problems, vomiting and nausea, polyneuropathy, nerve conduction abnormalities, increased risk of toxic encephalopathy, blisters with contact, cardiovascular disease, gastritis, retinopathy, Parkinson's-like symptoms (26, 31, 32).
Chloromethane	Liver, Neurological, Renal, reproductive system	Dizziness, nausea, vomiting; visual disturbance, stagger, slurred speech, convulsions, coma; liver, kidney damage; potential reproductive, teratogenic effects, potential occupational carcinogen (26, 33)
Ethylbenzene	Developmental (effects during periods when organs are developing) , Neurological	Carcinogen. Neurological changes or defects with birth. Potential increase for cancers related to exposures. Irritation of eyes, skin, mucous membrane; headache; dermatitis; narcosis, coma (26, 34, 35).
Hexachlorobutadiene	Eyes, skin, respiratory system, kidneys	In animals: Kidney failure, blood issues, fluid retention. Potential human carcinogen (26, 36).
Methylene Chloride	Eyes, skin, cardiovascular system, central nervous system	irritation eyes, skin; lassitude (weakness, exhaustion), drowsiness, dizziness; numb, tingling sensations in limbs; nausea; potential carcinogen (26, 37).
Propylene	Unknown	CNS toxicity, hyperosmolarity, hemolysis, cardiac arrhythmia, and lactic acidosis (38, 39, 40, 41).
Toluene	Immunological, Neurological, Eyes, Skin, Respiratory	Irritation to eyes, skin, nose, throat; choke, paroxysmal cough; chest pain, retrosternal soreness; nausea, vomiting, abdominal pain; bronchitis, bronchospasm, pulmonary edema; dyspnea, asthma; conjunctivitis, lacrimation; dermatitis, skin sensitization; ataxia, tremors, seizure, potential carcinogen; fetotoxic in animal studies (26, 42). Toluene may be contaminated with benzene (42, 43).

Chemical	Target Organs/Systems	Possible Health Effects
Hexane	Central Nervous System, Eyes, Skin, Respiratory systems	Brain and neurological changes and effects, neuropathy (44). n-Hexane: irritation eyes, nose; nausea, headache; peripheral neuropathy: numb extremities, muscle weak; dermatitis; dizziness; chemical pneumonitis (aspiration liquid) (26). Hexane isomers: irritation eyes, skin, respiratory system; headache, dizziness; nausea; chemical pneumonitis (aspiration liquid); dermatitis (26).
m/p-Xylene	Eyes, Nose, Throat, Lungs, Skin, Brain	High levels of xylene in air can cause eye and mucous membrane irritation, dyspnea, and central nervous system effects, such as headaches, dizziness, forgetfulness, delayed reaction times, and poor coordination (ATSDR, 2007).
Pentane	Eyes, skin, respiratory system, central nervous system	Irritation eyes, skin, nose; dermatitis; chemical pneumonitis (aspiration liquid); drowsiness; In Animals: narcosis (26).
Styrene	Multisystem	Changes in color vision, tiredness, feeling drunk, slowed reaction time, concentration problems, or balance problems. Hearing loss has been observed in animals exposed to extremely high concentrations of styrene. Changes in the lining of the nose and damage to the liver has also been observed in animals exposed to high concentrations of styrene. Irritation of eyes, nose, respiratory system; headache, confusion, malaise, drowsiness, unsteady gait; narcosis; defatting dermatitis; possible liver injury; reproductive effects. Anticipated human carcinogen (26, 45).
Toxic Organic Halogenated Dioxins and Furans		
1,2,3,4,6,7,8 HPCDD	N/A	Eye irritation, chloracne, liver damage. Insufficient data to support carcinogenic properties (46).
1,2,3,4,7,8,9 HPCDF	Multisystem Carcinogen	Carcinogen
1,2,3,4,7,8 HXCDF	Multisystem Carcinogen	Carcinogen
1,2,3,6,7,8 HXCDF	Multisystem Carcinogen	Carcinogen

1,2,3,7,8,9 HXCDF	Multisystem Carcinogen	Carcinogen
1,2,3,7,8 PECDF	Multisystem Carcinogen	Carcinogen, Skin cancer, lung cancer, brain cancer
2,3,4,7,8 PECDF	Multisystem Carcinogen	Carcinogen
2,3,7,8 TCDF	Multisystem Carcinogen	Carcinogen
Chemical	**Target Organs/Systems**	**Possible Health Effects**
Octachlorodibenzofuran	N/A	No human data to support carcinogenic properties found from this chemical.
1,2,3,4,6,7,8 HPCDF	Brain, Central Nervous System, Lungs, Others not specified due to lack of evidence	ALS, Cancer
1,2,3,4,7,8 HXCDD	Unknown	Carcinogen
1,2,3,6,7,8 HXCDD	Unknown	Carcinogen
1,2,3,7,8,9 HXCDD	Unknown	Carcinogen
1,2,3,7,8 PECDD	Unknown	Acute toxicity, long term exposure toxic
2,3,4,6,7,8 HXCDF	Eyes, Mucus Membranes, other soft tissue and moist organs	Eye irritation, serious eye damage, long lasting harmful effects to aquatic life are noted, acute toxicity.
2,3,7,8 TCDD	Developmental (teratogen), immune, hepatic, lymphatic, respiratory systems	allergic dermatitis, chloracne, lung cancer, soft tissue sarcomas, lymphoma, stomach carcinoma; GI distress in animals: carcinogen , in animals: hemorrhage, in animals: kidney damage, in animals: liver damage, eye irritant, porphyria, possible reproductive effects , possible teratogenic effects (7,8).

Dioxin-Like Chemicals	
Octachlorodibenzo-p-dioxin	Of the dioxins and furans measured in the U.S. representative subsamples of NHANES 1999-2000, 2001-2002, and 2003-2004, octachlorodibenzo-p-dioxin typically was present in the highest concentration, but contributed little to the TEQ, with the other commonly detected dioxin and furan congeners being more than eight-fold lower in concentration. Levels of octachlorodibenzo-p-dioxin that were similar to slightly higher than those in these NHANES subsamples were seen in a representative pooled sampling New Zealander residents aged 15 years and older obtained during 1997-1998 and also in a small convenience sample of German residents aged 18-71 years in 1996 (Bates et al., 2004; Papke et al., 1998; CDC, 2013). Similar levels were also found in 232 Belgian blood donors in 2000 (Debacker et al., 2007).
Hexachlorodibenzo-p-dioxins	The three major hexachlorodibenzo-p-dioxins are assigned equal TEF values, but the 1,2,3,6,7,8-hexachlorodibenzo-p-dioxin often demonstrated multifold higher concentrations than the other two hexachlorodibenzo-p-dioxins; about six times higher in the NHANES 2001-2002 subsample (CDC, 2013). The unadjusted geometric mean levels of 1,2,3,6,7,8-hexachlorodibenzo-p-dioxin in 2003-2004 and in 2001-2002 were 34.6 vs. 17.2 pg/g of lipid, respectively. The geometric mean levels of 1,2,3,6,7,8-hexachlorodibenzo-p-dioxin in the 2001-2002 subsample were slightly higher than levels in either the German or New Zealand study mentioned above (Bates et al., 2004; Papke et al., 1998). A convenience sample of Japanese men and women aged 20-76 years studied during 1996-1997 also showed lower median levels than levels in the NHANES 2001-2002 subsample (Arisawa et al., 2003; CDC, 2013).
1,2,3,7,8-Pentachlorodibenzo-p-dioxin	In prior NHANES surveys, 1,2,3,7,8-pentachlorodibenzo-p-dioxin concentrations were nearly 60-fold lower than octachlorodibenzo-p-dioxin levels (at the comparable percentiles) (CDC, 2013), but because of a 10,000-fold greater TEF (equal to that of TCDD), the contribution of 1,2,3,7,8-pentachlorodibenzo-p-dioxin to the total TEQ would be about 160 times greater than the octachlorodibenzo-p-dioxin. Levels of 1,2,3,7,8-pentachlorodibenzo-p-dioxin for the total population at the 95th percentile in the NHANES 2001-2002 and 2003-2004 subsamples were 15.8 pg/g and 11.0 pg/g lipid, respectively. In 1996, a convenience sample of German residents aged 18-71 years showed that levels of 1,2,3,7,8-pentachlorodibenzo-p-dioxin at the 95th percentile were 9.9 pg/g lipid (Papke et al., 1998). The 95th percentile of a group of workers with distant past trichlorophenol exposure was about twice as high as the 95th percentile for adults in NHANES 2001-2002 (CDC, 2013; Collins et al., 2006).

2,3,7,8-Tetrachlorodibenzo-p-dioxin	TCDD is considered the most potent of the dioxin-like chemicals and environmental exposure usually results in very low serum concentrations. In the NHANES 2003-2004 subsample, the 95th percentile for the total population (12 years and older) was 5.2 picograms/gram (pg/g) of lipid. In 1996, the 95th percentile for lipid-adjusted serum TCDD levels in 139 Germans aged 18-71 years was 4.3 pg/g of lipid, with that percentile comprising mainly older individuals (Papke, 1998). In contrast, the most highly exposed females following the Seveso, Italy, factory explosion had median lipid adjusted levels of 272 pg/g lipid in 1976 (Eskenazi et al., 2004). TCDD levels in chemical plant workers with higher exposures have ranged as high as 2,000 pg/g lipid (IARC, 1997). Median serum TCDD levels measured in chemical production workers 15 years after workplace exposure ended were 68 pg/g of lipid (Calvert et al., 1996; Calvert et al., 1999). TCDD levels in the U.S. general population were also lower than workers with past trichlorophenol exposure (Collins et al., 2006) and lower than Vietnam veterans 20 years after duty-related exposure to Agent Orange (median serum TCDD concentration was 12.2 pg/g of lipid) (Henriksen et al., 1997).
Polychlorinated dibenzofurans	Of the polychlorinated dibenzofurans, the following could be characterized at the 95th percentiles (or lower) in the NHANES 1999-2000, 2001-2002 and 2003-2004 subsamples:1,2,3,4,6,7,8-heptachlorodibenzofuran, 1,2,3,4,7,8-hexachlorodibenzofuran, 1,2,3,6,7,8-hexachlorodibenzofuran, and 2,3,4,7,8-pentachlorodibenzofuran. Generally, these levels are similar to other large population studies. In 237 workers with past exposure to trichlorophenol, where little polychlorinated dibenzofuran exposure would be expected, higher percentiles values were similar to a referent population and to the NHANES 1999-2000 and 2001-2002 subsamples (Collins et al., 2007; CDC, 2013). In 232 Belgian blood donors from the year 2000, the geometric mean level of 1,2,3,4,6,7,8-heptachlorodibenzofuran was several times lower than the geometric mean value in the NHANES 2001-2002 subsample of adults and the other dibenzofurans examined in the Belgian donors were lower than the limits of detection in NHANES 2000-2001 (CDC, 2013; Debacker et al., 2007). In Yucheng rice oil contamination victims when examined 15 years after their exposure, levels of the polychlorinated dibenzofurans were still hundreds of times higher than in levels for the U.S. population observed in the NHANES subsamples (Hsu et al., 2005).
Coplanar PCBs	The coplanar PCBs typically contribute less than about 15% to the total TEQ in the U.S. population (Ferriby et al., 2007). In the NHANES 2001-2002 subsample, the geometric mean levels of PCBs 126 and 169 for adults aged 20 years and older were similar or slightly lower than those reported from a representative pooled sample of New Zealanders in 1996-1997 (Bates et al., 2004; CDC, 2013) and from a smaller sample of non-occupationally exposed men and women aged 20-76 years in Japan in 1999 (Arisawa et al., 2003). Higher levels of these PCBs have been reported for persons consuming sport fish caught in the Great Lakes region (Turyk et al., 2006).In 311 residents of northern Italy, serum PCB 126 and 169 were not detectable, though other PCBs tended to be higher than in the recent NHANES subsamples (Apostoli et al., 2005; CDC, 2013).

Mono-ortho-substituted PCBs	Of the mono-ortho-substituted PCB congeners, the most frequently detected in general population studies are PCBs 118 and 156. Of these, PCB 118 levels were higher than levels of PCB 156 in the NHANES 1999-2000, 2001-2002, and 2003-2004 subsamples, although PCB 156 contributes more to the TEQ because its TEF is five-fold greater than the TEF of PCB 118. Although these PCBs are relatively less potent (i.e., lower TEFs), their contribution to the total TEQ in the U.S. population is about 25% (Ferriby et al., 2007) since they are present in much higher concentrations than are the coplanar PCBs, dioxins, and furans. In a convenience sample of the U.S. population in 1988 (Patterson et al., 1994), levels of PCB 118 were five-fold higher than in the NHANES 1999-2002 subsamples (CDC, 2013). Comparable levels of PCB 156 levels in NHANES 1999-2000 were slightly lower than those reported for a Canadian population study in 1994 (Longnecker et al., 2000). In a referent population of 311 residents in northern Italy during 2001-2003, the 95th percentile levels of PCB 156 and PCB 118 were two to three times higher than for the NHANES 1999-2002 subsamples (Apostoli et al., 2005; CDC, 2013). Levels of PCB 156 and PCB 118 were slightly higher in a Swedish study of 150 men than in the NHANES 1999-2000 subsample, possibly due to higher fish intake in the Swedish population (Glynn et al., 2000; CDC, 2013). However, in fish-consuming Japanese men and women studied during 1996-1997, PCB 118 levels at the 75th percentile were similar to levels in the NHANES 2001-2002 subsample (Arisawa et al., 2003). Finding a measurable amount of one or more of the polychlorinated dibenzo-p-dioxins, dibenzofurans, coplanar or mono-ortho-substituted biphenyls in serum does not mean that the level of one or more of these chemicals causes an adverse health effect. Biomonitoring studies of serum polychlorinated dibenzo-p-dioxins, dibenzofurans, coplanar or mono-ortho-substituted biphenyls provide physicians and public health officials with reference values so that they can determine whether or not people have been exposed to higher levels of polychlorinated dibenzo-p-dioxins, dibenzofurans, coplanar or mono-ortho-substituted biphenyls than levels found in the general population. Biomonitoring data can also help scientists plan and conduct research on exposure and health effects.

Notes

1. **Toxic Organic Halogenated Dioxins and Furans:** Specific information regarding many of the individual compounds is difficult to locate. Most have not been well studied and may simply be lumped together with other dioxins and furans. Chlorinated dibenzo-p-dioxins (CDDs) are regarded as human carcinogens based on sufficient animal data. Other health effects include chloracne; a severe dermatological condition characterized by acne-like lesions. Rashes, skin discoloration, and liver damage are also possible complications from exposure. CDDs have varying harmful effects and have been divided into eight groups based on the position of chlorine molecules. Exposure may occur through inhalation, orally, or with direct skin contact. How CDDs are broken down by the body is not well understood though CDDs may be found in higher concentrations in liver and adipose tissue after exposure (47). Chlorodibenzofurans (CDFs) have not been characterized for their ability to cause cancers and have not been shown to cause cancer in animal studies. Health effects in humans include dermatological conditions, eye irritation with discharge, vomiting, diarrhea, anemia, lung infections, numbness, nervous system effects, and liver changes. Children born to exposed mothers had skin irritation and more difficulty learning (48).

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