Dioxins – the most hazardous substance in structure fire environments

Post-structure fire settings, especially those where plastics, synthetic materials, or household products made with polyvinyl chloride (PVC) have burned, are where extremely hazardous and carcinogenic chemicals are created. One chemical in particular, dioxin, some consider to be the second most toxic chemical known to man, second only to radioactive waste.

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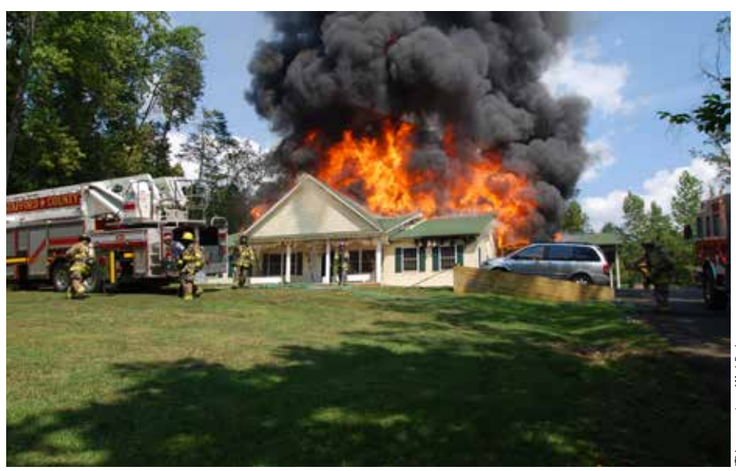
Not only is this substance extremely toxic to all life, it is also known to the World Health Organization as a member of the so-called 'Dirty Dozen' – a group of dangerous chemicals also referred to as persistent organic pollutants or 'POPs'.

POPs are chemicals of global concern due to their potential for long-range transport, persistence in the environment and atmosphere, ability to bio-magnify and bioaccumulate in ecosystems, as well as their significant negative effects on human health and the environment. Bioaccumulation is the accumulation of chemicals in organisms from the surrounding environment through skin absorption (by contact with contaminated surfaces, clothing and equipment), ingestion and inhalation.

The most commonly encountered POPs are unintentional by-products of many industrial processes, especially chlorinated dibenzo-p-dioxins (CDDs) and dibenzofurans.

CDD's are highly toxic compounds that are created during combustion processes, especially structure fires where PVC, plastics, paper and other chlorinated materials burn. The most toxic form of CDD is 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD), better known as 'Dioxin'.

▼ **Over 350,000 residential structure fires occur in the U.S. each year. In the UK, about 640 fires occur per million people.**



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What are dioxins and how are they created?

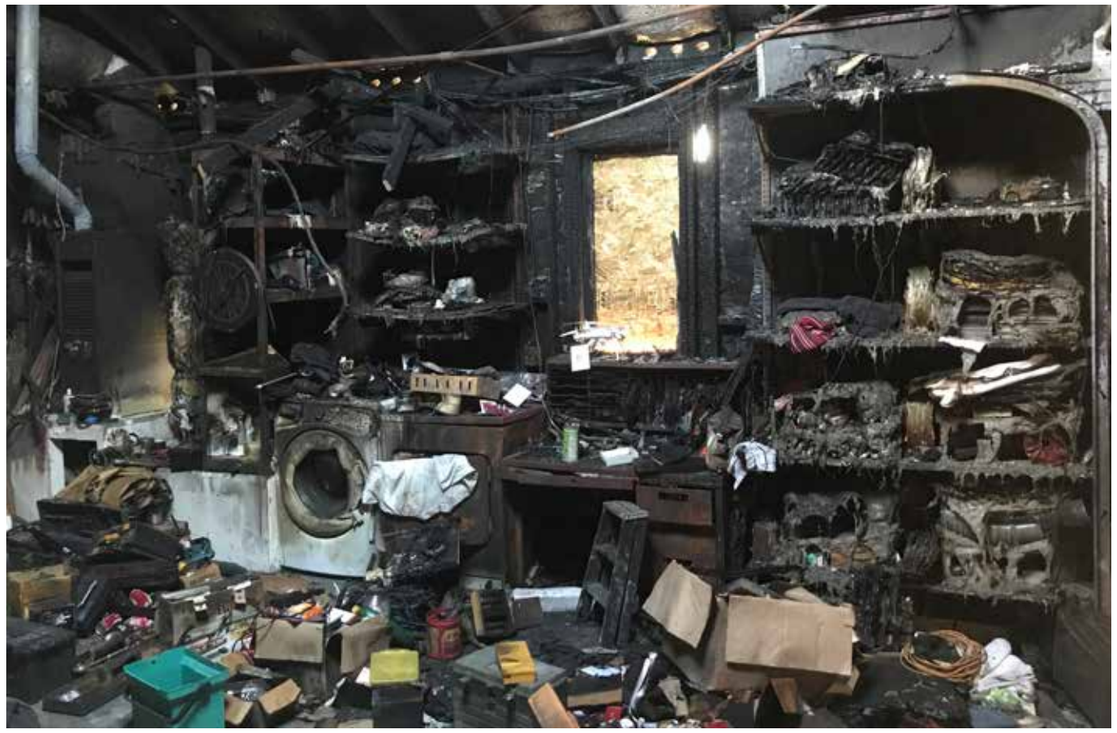
Dioxins are formed when products containing carbon and chlorine burn, especially plastic, paper, pesticides, herbicides or other products where chlorine is used in the manufacturing process. Dioxins do not typically exist in materials before they are burned. They are also especially prevalent in structure fires and wildfires.

Depending on the ambient temperature in a fire, dioxins can be adsorbed or chemically bound to smoke particles or remain in a vapour phase. Adsorption is when particles bond with one another, similar to how a magnet bonds with iron, rather than being absorbed like a sponge absorbs liquids.

TCDD can enter your body if you inhale contaminated particulate, have skin or eye contact with contaminated soot, ash, or other materials, or eat contaminated food. Since ultra-fine smoke particulate matter generated in fires is often less than 3 microns in size (half the size of a red blood cell), inhalation of dioxin-laden particulate can easily bypass the lungs and enter the bloodstream.

Human health risks of exposure to TCDD

Many adverse health effects have been well documented in scientific literature regarding TCDD. 'TCDD is considered the most toxic man-made substance and the fifth most toxic naturally occurring compound known to man. 2,3,7,8-TCDD is a potent toxicant in animals and has the potential to produce a wide spectrum of toxic effects in humans (EPA 1997c)'



▲ **Residential garage fires typically consume large quantities of plastics, PVC and synthetic materials.**

Here are some startling facts about TCDD:

1 Scientists say the toxicity of TCDD is exceeded only by radioactive waste. Short-term exposure to high levels of dioxins may result in skin lesions, such as chloracne. Long-term exposure is linked to a vast array of diseases and ailments, including impairment of the immune system, the developing nervous system, the endocrine system and reproductive functions.

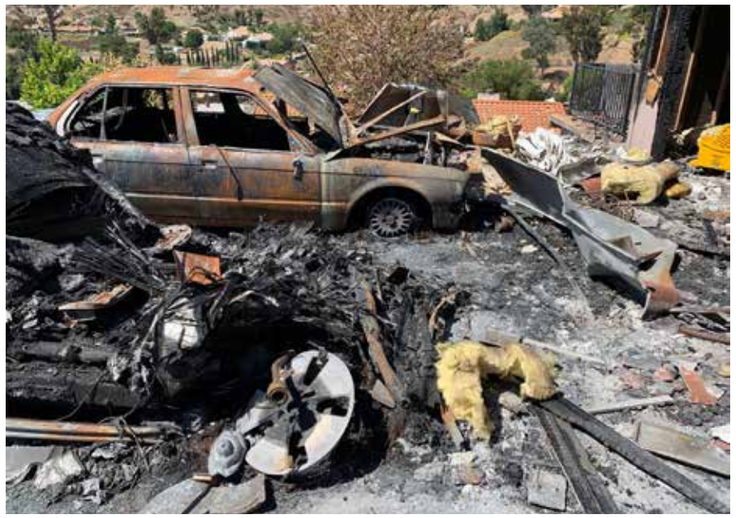
Other adverse health effects may include cardiovascular disease, diabetes, cancer, porphyria, endometriosis, early menopause, reduced testosterone and thyroid hormones, altered immunologic response and altered metabolism.

Diseases which have been linked to dioxin seem endless. Ingesting dioxin can also result in congenital malformations, spontaneous miscarriages, and a fatal, slow wasting syndrome similar to AIDS. Dioxin is strongly suspected of contributing to pathology of the urinary and haematological systems, growths in the colon, gallbladder complications, multiple myeloma, and lung, larynx and prostate cancer.

According to researcher Joe Thornton, 'Dioxin's health effects include endocrine disruption, reproductive impairment, infertility, birth defects, lowered sperm counts, impaired neurological development, damage to the kidneys, and metabolic dysfunction. There is no evidence that there is a safe level of dioxin exposure below which none of these effects will occur'

2 TCDD is an endocrine-disrupting chemical that can threaten the development of new-borns. The endocrine system is a series of glands that produce and secrete hormones that the body uses for a wide range of functions, including respiration, metabolism, sensory perception, sexual development and growth.

The US National Toxicology Program and the EPA have determined that TCDD is a proven human carcinogen. In July 2009, the US Institute of Medicine published a report that showed evidence of an association between exposure to TCDD and soft-tissue sarcoma, non-Hodgkin's lymphoma, chronic lymphocytic leukaemia, Hodgkin's disease, prostate cancer, multiple myeloma, as well as cancers of the larynx, lungs, bronchi and trachea.



◀ Residential structure fires can create immeasurable amounts of dioxins as well as other hazardous substances.

3 TCDD is on the Special Health Hazard Substance List because it is a teratogen. A teratogen is any agent that causes an abnormality following fetal exposure during pregnancy. Pregnant women and their developing infants are extremely vulnerable to the effects of TCDD.

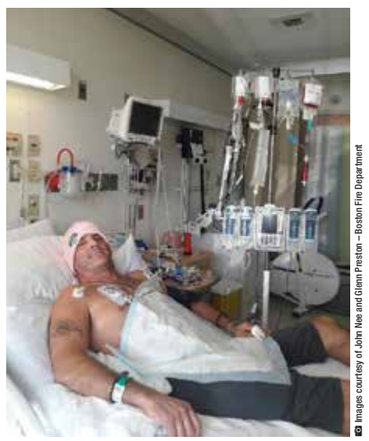
4 TCDD is genotoxic and a known mutagen. A mutagen is a physical or chemical agent that causes a mutation, which is a change in the DNA of a cell. TCDD alters the genetic structure of living cells. The effect TCDD has on cell structures and genes can be passed down to future generations. In 2012, a scientific study found that dioxin affects not only the health of an exposed rat but also unexposed descendants through a mechanism of epigenetic transgenerational inheritance.

When dioxin binds to an intracellular protein known as the aryl hydrocarbon receptor (AHR), the AHR can alter the expression, or function, of certain genes. The resulting cellular imbalance leads to a disruption in normal cell function and adverse health effects. The genetic effects of TCDD may skip a generation and reappear in third or subsequent generations.

5 TCDD is hepatotoxic (toxic to the liver), nephrotoxic (toxic to the kidneys), and embryotoxic (toxic to embryos).

6 TCDD causes birth defects and spontaneous miscarriages.

▼ Dermal absorption of toxic chemicals is of major concern to firefighter health.



Images courtesy of John Nee and Glenn Preston – Boston Fire Department

7 TCDD is neurotoxic. Neurotoxicity is a form of toxicity in which a biological, chemical, or physical agent has an adverse effect on the central and/or peripheral nervous system.

8 The International Joint Commission, comprised of the United States and Canadian governments, has publicly stated that zero exposure to dioxin is the only safe level. There is no permissible exposure limit set by NIOSH.

9 TCDD is bioaccumulative and becomes more concentrated with repeated exposure. Once internalized, they accumulate in body tissues, mainly body fat, resulting in chronic lifetime exposure (Schecter et al., 1994).

10 When calculating human exposures, dioxins are so toxic that they are measured in picograms – that is, trillionths (0.000000000001) of a gram. TCDD, even in picograms, is associated with severe health damage that can shorten the lives of people exposed to it.

11 In 1999, the Agency for Toxic Substances and Disease Registry (ATSDR) set a minimal risk level for dioxins and related compounds of 1.0 picogram (1 trillionth of a gram) toxicity equivalence (TEQ) per kilogram of body weight per day.

12 In certain animal species, 2,3,7,8-TCDD is so harmful that it can cause death after a single exposure.

13 No antidote for dioxin toxicity is known. Symptomatic and supportive care is the only known therapy.

More important facts about TCDD

1 TCDD was a key ingredient in Agent Orange that was used as a defoliant in the Vietnam war.

2 Half-life estimates for TCDD (the time required for TCDD to decrease by half) on surface soil range from 9 to 15 years, whereas the half-life in subsurface soil may range from 25 to 100 years.

3 Dioxins persist in the environment for a long time because they do not dissolve in water.

4 Photolysis (the decomposition of molecules by the action of light) is considered to be the most important degradation mechanism of gaseous dioxins in the atmosphere. However, laboratory evidence indicates that when dioxins interact with particles, photodegradation is reduced to insignificant levels.

5 The only known way to completely destroy TCDD is by incinerating it at temperatures over 1,550°F. (843°C).

6 Burning 1kg (2.20lb) of wood produces as much as 160 micrograms of total dioxins.

7 Barry Commoner, professor at Washington University, stated that: 'Many toxic chemicals are linked with a specific illness, such as lead and brain damage, or asbestos and mesothelioma. Others are linked with several illnesses. Dioxin is tied to such a large number of diseases because it is a cancer-enhancer. Dioxins intensify cancers which other toxins begin. They greatly enhance the activity of the enzyme system that converts most environmental carcinogens into active agents. In effect, dioxin influences tumor production by enhancing the activity of carcinogens. This is why dioxin has different effects on different people. For example, if a group of workers has already been exposed to chemicals which cause Hodgkin's disease, dioxin will speed up the process and they will have an increased rate of Hodgkin's disease progression. The human body tends to store dioxin in fatty tissue, and when people take in dioxin through food or air, it ends up stored inside of their cells.'

Firefighters are at the greatest risk of exposure to TCDD

Thirty years ago, firefighters were most frequently diagnosed with asbestos-related cancers. Today, the cancers are more often leukaemia, lymphoma, myeloma, oral, digestive, respiratory and urinary cancers. It is no coincidence that these are the same types of cancers known to be caused by exposure to TCDD.

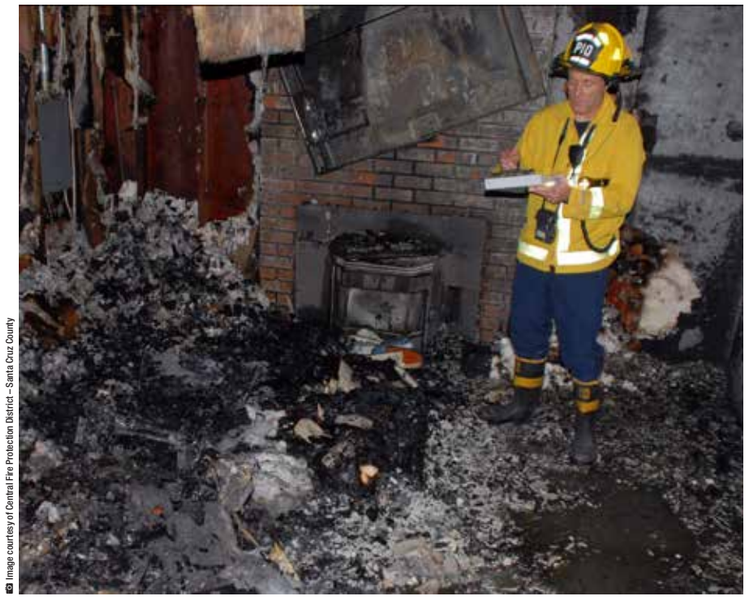


Image courtesy of Central Fire Protection District – Santa Cruz County

▲ Fire investigators are exposed to toxic chemicals, gases and particulate matter that can cause sickness, disease and even death.

Although firefighters wear state-of-the-art PPE, toxic chemicals often find their way through where they can be inhaled, ingested, or absorbed by the skin. Exposure to TCDD is likely to be one of the primary causes or at least a contributing factor for the high number of cancers, diseases and fatalities to the men and women in the fire service.

Fire investigators

Fire investigators typically spend hours and sometimes days inside fire damaged structures. They sift through smouldering debris and ash searching for the cause and origin of fires. Oftentimes PPE is regarded as cumbersome and not worn. Here investigators are exposed to TCDD and a myriad of other toxins in the ash as well as in the airborne particulate matter.

Turnout and textile contamination

Currently there are no scientifically proven methods to clean textiles contaminated with TCDD. In fact, the only known way to destroy TCDD is by incinerating it at temperatures over 1,500°F (843°C). TCDD is not water soluble, nor does it decompose when exposed to ozone or hydroxyls in the atmosphere.

If an attempt is made to clean smoke-damaged textiles that are contaminated with TCDD, heavy metals, or other toxic combustion by-products, then samples of the articles should be analysed after the cleaning by a qualified independent third-party laboratory to see if the cleaning was truly successful. This is particularly important for clothing, where TCDD and other toxic combustion by-products can come in contact with the skin and be absorbed.

For those in the fire service, turnout coats, trousers and other protective garments are regularly exposed to high concentrations of toxic substances, including TCDD. Although some fire departments use industrial-grade washing machines and detergents to clean their gear, periodic testing should be performed to verify if these cleaning methods are effective, or if hazardous substances, such as TCDD remain embedded in the fabric after cleaning.

For more information on fire- and smoke-related topics, read: *Addressing Toxic Smoke Particulates in Fire Restoration, Smoke Damaged Textiles – What Does Clean Mean?* These and other informational resources are available free of charge at: https://www.theredguidetorecovery.com/free-preparedness-recovery-tools/

For more information, go to www.theredguidetorecovery.com/free-preparedness-recovery-tools/