



Firefighters' exposure to halogenated chemicals

Lucas Beck
Julien Clément

Occupational and
environmental health



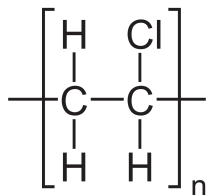
Summary

Halogenated chemicals
How are firefighters exposed?
Risk factors and health risks
Risk assessment
Relevant regulations
Recommendations

Halogenated Chemicals

- Elements : F, Cl, Br, I, At ,Ts
- High electronegativities
- Very reactive
- Example of a common halogenated product in use:

PVC



https://fr.wikipedia.org/wiki/Polychlorure_de_vinyle

						18 VIII A 8A
						2 He Helium 4.003
5 III A 3A	6 IV A 4A	7 V A 5A	8 VI A 6A	9 VII A 7A	10 VIII A 8A	11 I A 1A
B Boron 10.811	C Carbon 12.011	N Nitrogen 14.007	O Oxygen 15.999	F Fluorine 18.998	Ne Neon 20.180	
13 III A 3A	14 IV A 4A	15 V A 5A	16 VI A 6A	17 VII A 7A	18 VIII A 8A	
Al Aluminum 26.982	Si Silicon 28.086	P Phosphorus 30.974	S Sulfur 32.066	Cl Chlorine 35.453	Ar Argon 39.948	
31 III A 3A	32 IV A 4A	33 V A 5A	34 VI A 6A	35 VII A 7A	36 VIII A 8A	
Ga Gallium 69.723	Ge Germanium 72.631	As Arsenic 74.922	Se Selenium 78.972	Br Bromine 79.904	Kr Krypton 83.798	
49 III A 3A	50 IV A 4A	51 V A 5A	52 VI A 6A	53 VII A 7A	54 VIII A 8A	
In Indium 114.818	Sn Tin 118.711	Sb Antimony 121.760	Te Tellurium 127.6	I Iodine 126.904	Xe Xenon 131.294	
81 III A 3A	82 IV A 4A	83 V A 5A	84 VI A 6A	85 VII A 7A	86 VIII A 8A	
Tl Thallium 204.383	Pb Lead 207.2	Bi Bismuth 208.980	Po Polonium [209]	At Astatine 209.987	Rn Radon 222.018	
113 III A 3A	114 IV A 4A	115 V A 5A	116 VI A 6A	117 VII A 7A	118 VIII A 8A	
Nh Nihonium [286]	Fl Flerovium [289]	Mc Moscovium [289]	Lv Livermorium [293]	Ts Tennessine [294]	Og Oganesson [294]	

<https://sciencenotes.org/halogen-elements-list-and-facts/>

How are firefighters exposed?

Type	Fuel containing halogens	Main halogenated combustion products
Wildfire	-	-
Structure, waste	PVC, Flame retardants, Pipes, Siding, Flooring, wire insulation, Legacy preservatives, PCBs	HCl, HF, HBr, chloro-aliphatic and chloro-aromatic hydrocarbons (Cl-PAHs), Dioxins and Furans (PCDD/Fs) , Per-fluorinated chemicals, PCBs, PBDE
Vehicle	Battery	HCl, HF, PCDD/Fs , Cl-PAHs, COF ₂ , POF ₃

Risk factors for firefighters

“Although levels varied between the two experiments, polyhalogenated dibenzofurans were generated in all simulated fires indicating the high likelihood that these compounds are generated in most fire debris. These results are concerning due to the potential of constant exposure of firefighters to these types of compounds.”

Organtini, Kari L. et al. 2015. “Quantitative Analysis of Mixed Halogen Dioxins and Furans in Fire Debris Utilizing Atmospheric Pressure Ionization Gas Chromatography-Triple Quadrupole Mass Spectrometry.”

Aggravating factors:

- Environments with halogenated fuels
- Working solely in city environments
- Frequent exposure

Protective factors:

- Protective equipment
- Hygiene, material maintenance
- Well instructed firefighters

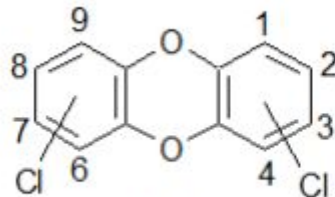
Health risks of PCDD/Fs

Exposure mechanisms:

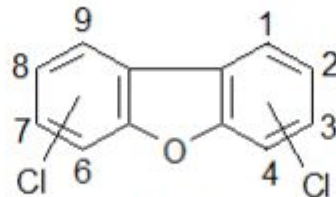
- Inhalation
- Skin contact
- More rarely ingestion

Health effects:

- Skin lesions
- Reduced reproduction
- Impaired immunology
- Carcinogenic
- Hepatotoxicity
- Developmental issues



CDDs

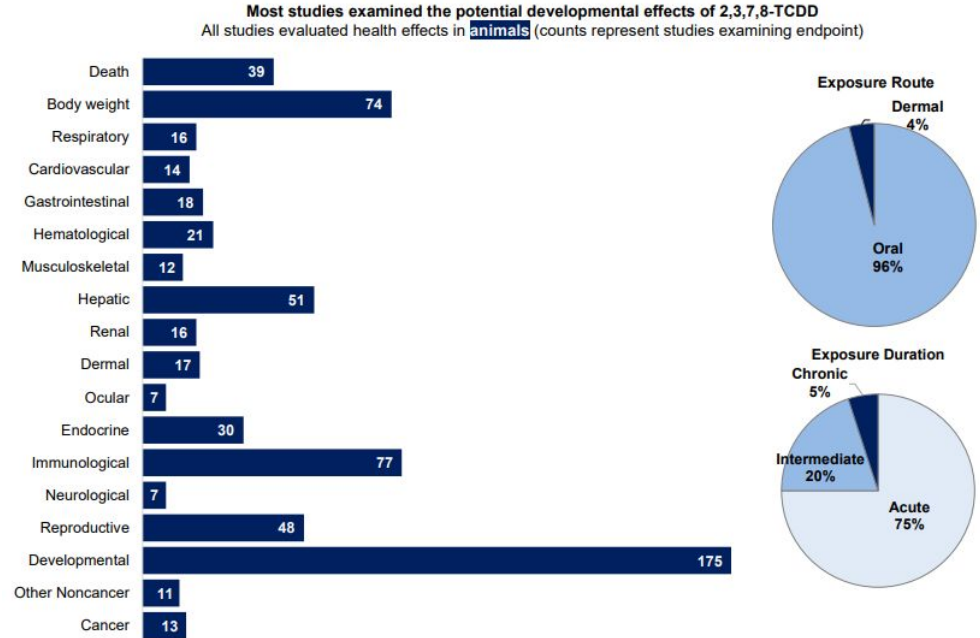


CDFs

Evidence of toxicology on animals

- Research on animals (mostly rats) is well established and toxicology is well described
- Most of the research focused on oral exposure and acute durations
- Conclusions are that these halogenated chemicals are highly toxic

Figure 2-2. Overview of the Number of Animal Studies Examining 2,3,7,8-Tetrachlorodibenzo-*p*-Dioxin (2,3,7,8-TCDD) Health Effects*



*Includes studies discussed in Chapter 2. A total of 393 studies (including those finding no effect) have examined toxicity; most studies examined multiple endpoints.

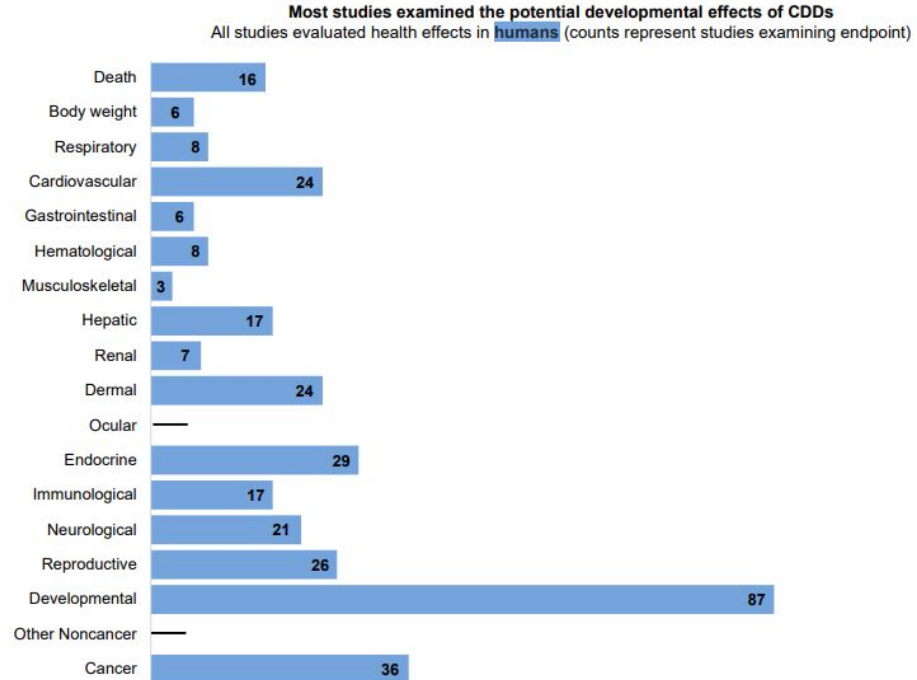
Toxicological Profile for Chlorinated Dibenzo-*p*-Dioxins, Agency for Toxic Substances and Disease Registry,

<https://wwwn.cdc.gov/TSP/ToxProfiles/ToxProfiles.aspx?id=366&tid=63>

Evidence of toxicology on humans

- Research on humans usually cannot prove direct toxic implications
- Most likely very toxic compounds
- Rarely specifically analyzed on firefighters

Figure 2-1. Overview of the Number of Studies Examining Chlorinated Dibenzo-*p*-Dioxins (CDDs) Human Health Effects*



*Includes studies discussed in Chapter 2. A total of 258 studies (including those finding no effect) have examined toxicity; most studies examined multiple endpoints.

Toxicological Profile for Chlorinated Dibenzo-*p*-Dioxins, Agency for Toxic Substances and Disease Registry,

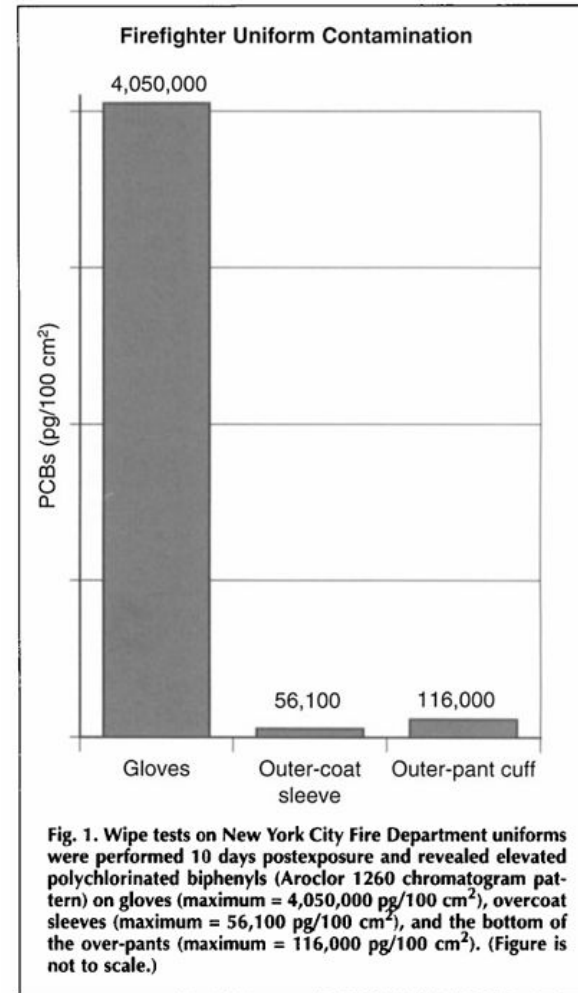
<https://wwwn.cdc.gov/TSP/ToxProfiles/ToxProfiles.aspx?id=366&tid=63>

- Identify, analyze and evaluate the risks associated with firefighters' exposure to hazardous chemicals
- PCBs, PCDDs and PCDFs
- Analyze through an example from NYC

- On September 7, 1998, a fire broke out at a Con Edison electrical transformer in Staten Island.
- They wore a unadapted uniform (not HAZMAT)
- Ten days after the incident, FDNY was informed of the contamination. Sixty personnel were exposed, and a health surveillance program was launched.
- This included medical exams and testing for PCBs, PCDDs, and PCDFs.

Exposure mechanisms:

- Inhalation
- Skin contact
- Ingestion
- breathing device used only if smoke was present
- Uniform was analyzed
- No decontamination routine



- 2-3 weeks, 3 month and 9 month post exposure
- 73% had a significant decrease in serum level at the time of follow-up.

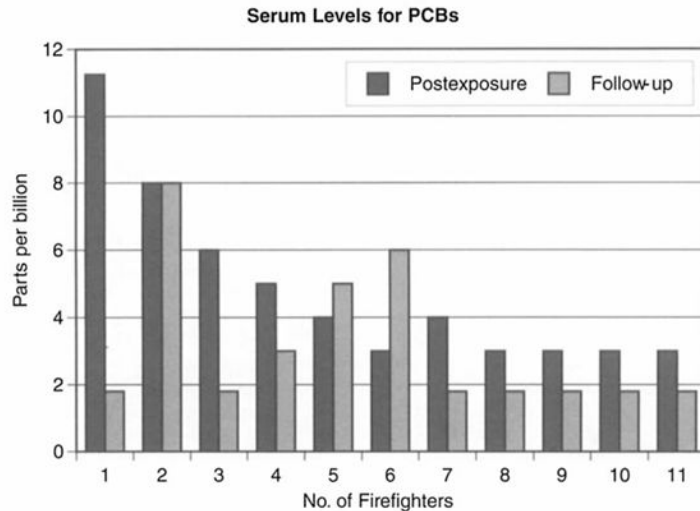


Fig. 4. Of the 11 subjects with serum polychlorinated biphenyl (PCB) levels > 1.9 ppb on initial postexposure testing, and who presented for follow-up testing, 8 (73%) had a significant decrease ($p = .05$) in serum PCB levels. In 1 firefighter, there was no change in serum PCB levels, and in 2 firefighters there was an increase in serum PCBs.

- 55% with initial symptom (including 3 brief medical leaves)

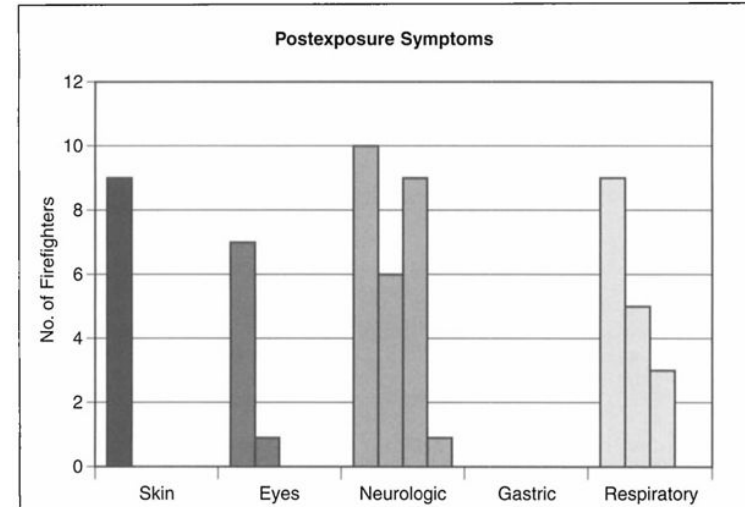
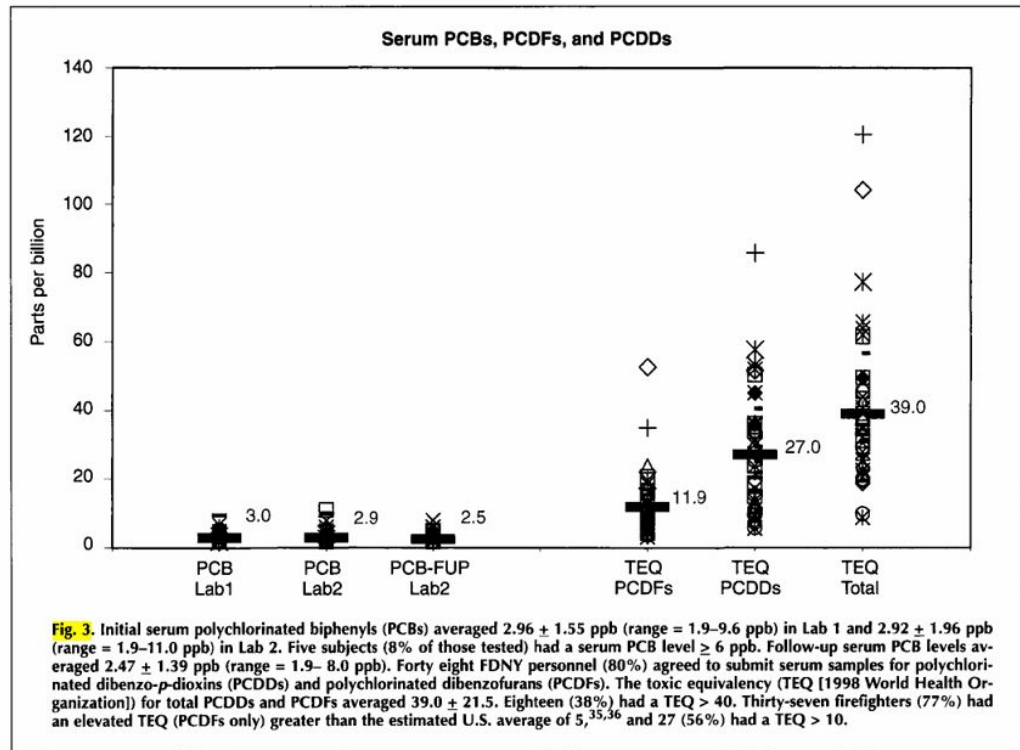


Fig. 2. During comprehensive medical examinations (i.e., immediate and 2-3 wk postexposure), 32 of 58 (55%) firefighters reported initial symptoms. Nine firefighters reported skin irritation and/or itching with nonspecific findings on exam. Twenty-six firefighters (47%) reported neurologic complaints, of whom 2 required brief medical leave resulting from headache and anxiety. Gastrointestinal complaints or findings were not reported. Seventeen firefighters (29%) reported respiratory complaints, none of which were incapacitating or prolonged in duration.

Medical analysis

- TEQ (Toxicity equivalent)
- Average US total TEQ for PCDFs and PCDDs is 5
- 40% have more than 40 TEQ



So what about the risk?

Reminder:

- 55% with initial symptom (including 3 brief medical leaves)
- 40% have more than 40 TEQ
- 73% had a significant decrease in serum level at the time of follow-up.

BUT:

- They were falsely informed
- They did wear a unadapted uniform

Conclusion:

- High risk when little to no protection

Relevant Regulations

- In NYC, the HAZMAT incident is declared if PCBs levels > 30 ppm.
 - Based on database or declaration if no data
- A health program is launched in response to larger incident
- In Switzerland, principle of prevention → heavier equipment all time but more adapted in case of chemical hazard.
- Construction norm that reduce the risk of contamination in case of fire (for the recent building)

- Improved decontamination protocols for uniforms and gear.
- Use of specialized chemical-resistant suits in similar incident.
- Routine health surveillance for all firefighters to monitor hazardous chemicals



Thank you

References

Hazard identification, Background information:

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Ruokojärvi, Päivi, Marjaleena Aatamila, and Juhani Ruuskanen. 2000. "Toxic Chlorinated and Polyaromatic Hydrocarbons in Simulated House Fires." *Chemosphere* 41 (6): 825–28. [https://doi.org/10.1016/S0045-6535\(99\)00549-4](https://doi.org/10.1016/S0045-6535(99)00549-4).

Risk assessment, regulation:

Hsu, Jing-Fang, How-Ran Guo, Hsueh Wen Wang, Chin-Kun Liao, and Pao-Chi Liao. 2011. "An Occupational Exposure Assessment of Polychlorinated Dibenzo-p-Dioxin and Dibenzofurans in Firefighters." *Chemosphere* 83 (10): 1353–59. <https://doi.org/10.1016/j.chemosphere.2011.02.079>.

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