

# Exposure and health risks potentially posed to petroleum storage tank cleaners by volatile organic compounds

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**Abstract** This study models and assesses the significance of risks to health potentially posed to individuals exposed to volatile organic compounds (VOCs) due to being occupationally engaged in cleaning petroleum storage tanks. Exposure processes include hydrocarbon vapor inhalation, ingestion via hand-to-mouth contact, and dermal exposure. Under confined space entry regulations, tank cleaners must wear protective clothing and a breathing apparatus. However, such regulations are recent and sometimes violated. Several factors were found to influence exposure of unprotected individuals cleaning tanks. One factor is climate. This paper reports on a study of tanks in south Texas, which is sunny and hot during most of the year. Solar irradiation of metal surfaces may elevate internal temperatures above ambient air temperatures. Vaporization then elevates airborne hydrocarbon concentrations, and ventilation reduces them, producing a dynamic equilibrium. Human entry, however, disturbs this equilibrium by agitating petroleum residuals. Based upon the above considerations, we have modeled petroleum fuel storage tank dynamics in a case study. We considered three cases: manways closed, manways open, and manways actively ventilated. For CASE I, the concentration of each pollutant in the vapor phase was calculated using Raoult's Law. CASE II and CASE III applied Raoult's Law and also evaluated a mass balance via a mass transfer coefficient derived using the Reynolds Number and the Schmidt Number. Based upon empirical data, the velocity of the air within the tank was assumed to be 1.6 mph. Outputs of the case study included the steady-state concentration of each constituent and time required to reach it. Health risk assessment was conducted to quantify non-cancer risks posed by individual substances (the hazard quotient, HQ) and by simultaneous and/or sequential exposure to multiple substances (the hazard index, HI). During hot months, gross exceedances of acceptability criteria for acute and

chronic exposures to mixed solvent vapors occurred. The HI exceeded the acceptability criterion by more than three orders of magnitude. The HI for chronic occupational neurological risks exceeded the acceptability criterion by more than two orders of magnitude. This result is consistent with observed neurological deficits among tank cleaners, such as depression of performance on memory tests among crew members who had worked during hot months. Finally, in such instances, eight-hour time-weighted average mixed-solvent vapor concentrations can exceed half of lethal levels, suggesting that tank cleaners can potentially approach lethal exposure routinely during hot seasons.

## Introduction

### Purpose

Industry powered by fossil fuels has characterized much of the current millennium. A legacy of this epoch in human history has been global deployment of heating systems, engines powered by petroleum products, and industrial plants using petroleum reactants to synthesize petrochemical products, such as plastics. The global landscape, as a result, has become strewn with the relatively primitive vessels needed to contain petroleum fuels, both above ground and underground, namely, steel tanks.

Much attention has been focused in recent years upon leakage of corroded steel tanks as a source of human health risk arising from soil and groundwater contamination. In contrast, relatively little attention has been focused upon health risks posed by direct human exposure to petroleum products contained in steel tanks. To elucidate this issue, we assess the significance of risks to health potentially posed by volatile organic compounds (VOCs) to individuals occupationally engaged in cleaning and refurbishing petroleum storage tanks.

### Scope

The size of tanks containing petroleum products is a critical parameter determining human exposure. The most common tanks have low volume, exemplified by automotive fuel tanks. A smaller fraction of tanks have high volume, exemplified by fuel tanks on ships, including tanks powering diesel ship engines, and tanks transporting fuels from refineries to ports where off-loading occurs. The most (in)famous example of the latter is the Exxon Valdez, which spilled its petroleum cargo in Alaska, damaging sensitive coastal ecosystems. Routinely, however, off-loading is accomplished via pipelines trans-

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