
Chemical Human Health Hazards Associated With Oil Spill Response

Regulatory Analysis and Scientific Affairs

PUBLICATION NUMBER 4689
AUGUST 2001

CHEMICAL HUMAN HEALTH HAZARDS ASSOCIATED WITH OIL SPILL RESPONSE

**Prepared for the
American Petroleum Institute
1220 L Street, NW
Washington, DC 20005**

Prepared by

Evan C. Thayer
Anita George-Ares
Robert T. Plutnick
Ruth A. Kaufman

Exxon Biomedical Sciences, Inc.
Mettlers Rd. CN 2350
East Millstone, NJ 08875-2350

August 2001

FOREWORD

API PUBLICATIONS NECESSARILY ADDRESS PROBLEMS OF A GENERAL NATURE. WITH RESPECT TO PARTICULAR CIRCUMSTANCES, LOCAL, STATE, AND FEDERAL LAWS AND REGULATIONS SHOULD BE REVIEWED.

API IS NOT UNDERTAKING TO MEET THE DUTIES OF EMPLOYERS, MANUFACTURERS, OR SUPPLIERS TO WARN AND PROPERLY TRAIN AND EQUIP THEIR EMPLOYEES, AND OTHERS EXPOSED, CONCERNING HEALTH AND SAFETY RISKS AND PRECAUTIONS, NOR UNDERTAKING THEIR OBLIGATIONS UNDER LOCAL, STATE, OR FEDERAL LAWS.

NOTHING CONTAINED IN ANY API PUBLICATION IS TO BE CONSTRUED AS GRANTING ANY RIGHT, BY IMPLICATION OR OTHERWISE, FOR THE MANUFACTURE, SALE, OR USE OF ANY METHOD, APPARATUS, OR PRODUCT COVERED BY LETTERS PATENT. NEITHER SHOULD ANYTHING CONTAINED IN THE PUBLICATION BE CONSTRUED AS INSURING ANYONE AGAINST LIABILITY FOR INFRINGEMENT OF LETTERS PATENT.

All rights reserved. No part of this work may be reproduced, stored in a retrieval system, or transmitted by any means, electronic, mechanical, photocopying, recording, or otherwise, without prior written permission from the publisher. Contact the publisher, API Publishing Services, 1220 L Street, N.W., Washington, D.C. 20005.

Copyright ©2001 American Petroleum Institute

ACKNOWLEDGMENTS

The following people are recognized for their contributions of time and expertise during the preparation of this report:

API STAFF CONTACT

Thomas Purcell, Regulatory Analysis and Scientific Affairs

MEMBERS OF THE OIL SPILL SCIENCE AND TECHNOLOGY WORK GROUP

David Fritz, Chairperson, BP
Dan Allen, Chevron North America E&P Company
Ken Bitting, US Coast Guard R&D Center
Bon Britton, US Fish and Wildlife Service
Michael Carter, US Maritime Administration
Jim Clow, Equiva Services
Bill Dahl, ExxonMobil Research & Engineering Co.
Donald Erickson, Bay West, Inc.
Ronald Goodman, Imperial Oil Ltd.
Brad Hahn, State of Alaska
Bela James, Equilon Enterprises, LLC
Robin Jamail, Texas General Land Office
Roger LaFerriere, US Coast Guard
Jerry Langley, Williams Pipe Line Company
Stephen Lehamann, NOAA
Richard Lessard, ExxonMobil Research and Engineering Company
Dan Leubecker, US Maritime Administration
Edwin Levine, NOAA
Jason Maddox, NOAA
Joseph Mullin, Minerals Management Service
William Nichols, U.S. EPA
Douglas O'Donovan, Marine Spill Response Corporation
W. Michael Pittman, US Coast Guard
Ninette Sadusky, US Navy SUPSALV
Jim Sanders, CITGO Pipeline Company
Dana Slade, Lakehead Pipe Line Company
Jean Snider, NOAA
Alexis Steen, ENTRIX Corp.
Robert Urban, PCCI
Carol Voigt, CITGO Petroleum Corporation

The American Petroleum Institute recognizes Woodward Clyde Consultants and ENSR Consulting and Engineering for their assistance in the completion of this project. LCDR Roger LaFerriere and LCDR David Stalfort, both from the US Coast Guard, are also recognized for their technical review and creative contributions to the final preparation of this project.

Copyright American Petroleum Institute

TABLE OF CONTENTS

EXECUTIVE SUMMARY	ES-1
1. INTRODUCTION	1-1
2. ENVIRONMENTAL FATE AND EXPOSURE CONSIDERATIONS	2-1
ENVIRONMENTAL FATE	2-1
Introduction	2-1
Spreading	2-2
Drift.....	2-3
Evaporation	2-3
Dissolution	2-4
Dispersion	2-4
Emulsification	2-5
Sedimentation.....	2-6
Biodegradation	2-6
Photooxidation	2-7
Fate of Oil Onshore	2-8
Fate Summary	2-9
EXPOSURE CONSIDERATIONS	2-9
Time Factors.....	2-9
Nature of Products, Spill Scenario and Tasks.....	2-10
Regulatory Issues.....	2-11
3. HEALTH HAZARDS OF PRODUCTS AND COMPONENTS OF CONCERN	3-1
IDENTIFICATION OF PRODUCTS AND COMPONENTS OF CONCERN	3-2
Products of Concern	3-2
Crude Oil.....	3-2
Gasoline	3-3
Middle Distillate Fuels.....	3-4
Heavy Fuel Oil	3-5
Asphalt	3-6

Components of Concern	3-7
Benzene.....	3-7
n-Hexane	3-8
Hydrogen Sulfide.....	3-8
Naphthalene.....	3-10
Polycyclic Aromatic Hydrocarbons.....	3-11
Tetramethyl and Tetraethyl Lead	3-12
Toluene	3-13
Trimethyl Benzene	3-14
 4. SUMMARY AND CONCLUSIONS	 4-1
 REFERENCES	 R-1

LIST OF FIGURES

Figures

1-1 Elements of Risk Assessment and Risk Management.....	1-2
2-1 Processes Acting on Spilled Oil	2-2

LIST OF TABLES

Table

2-1 Exposure Limits for Components of Concern in Crude Oils.....2-13

3-1 Relative Potential Health Concern for Components of Petroleum
Products.....3-1

EXECUTIVE SUMMARY

This report provides an overview of potential human health hazards encountered by personnel involved with petroleum product spills or leaks. Widely distributed products are covered, including crude oil, gasolines, various middle distillates (e.g., kerosene, jet fuel, diesel fuel, and home heating oil), heavy fuel oil, and asphalt. The main objective is to define basic components and products of concern based on their inherent toxicity and potential risks to oil spill workers. In addition, environmental factors that may affect the risk of exposure to the various components are discussed. A brief summary of important exposure considerations is included (Section 4).

In order to discuss the potential human health hazards associated with these petroleum hydrocarbon products, it is helpful to break down the products into the various components of concern and understand the toxicology of those components. Table 2-1 links the various products to their associated components of concern. The main components of health concern in Table 2-1 include benzene, hydrogen sulfide, n-hexane, naphthalene, toluene, trimethyl benzene, polycyclic aromatic hydrocarbons (PAHs) and, in specific instances, organic lead compounds.

Acute health hazards associated with many components of concern include depression of the central nervous system, and irritation to the skin, eyes, and respiratory tract. Chronic exposure to some components, such as benzene and polycyclic aromatic hydrocarbons, has been associated with cancer risks.

Other than the toxicological properties of the components and products of concern, other factors affect the nature of health hazards during spill response activities. These include environmental conditions, the physical characteristics of the products, and the type of spill or leak scenario and time factors. The environmental fate of a spilled material is determined by various mechanisms including evaporation, spreading, dissolution, drift, dispersion, and emulsification.

Many of the more toxic components evaporate rapidly, so risk of exposure to airborne contaminants diminishes greatly with time. This is especially true for one of the most inherently toxic components, hydrogen sulfide. Benzene and other very light hydrocarbons may evaporate

within the first 6-8 hours after a spill. As the material continues to weather, physical contact becomes the main route of exposure. Chemical hazards relating to oil treating agents such as dispersants or chemical cleaners are not evaluated in this report.

Section 1

INTRODUCTION

Oil spills can originate from many sources. Many spill incidents are attributed to short-term, high volume releases from pipeline breaks, vessel casualties such as sinking, grounding, and collision, and from facilities during fuel or cargo transfers. The potential human health hazards associated with long-term chronic exposure to petroleum fuels during petroleum *production* operations have been reviewed and summarized (CONCAWE, 1985); however, the short-term health hazards to human health from petroleum *spills* have not been discussed in detail (API, 1997).

It is important to understand potential hazards associated with an oil spill so that efforts can be made to reduce acute health impacts, particularly during emergency response. The potential health hazards from a petroleum spill depend on many factors, the most important are the:

- Chemical and physical properties and composition of the petroleum product;
- Environmental conditions both during and after the release;
- Location and types of tasks performed by the oil spill workers;
- Control measures used to minimize worker exposure.

The objective of the report is to identify the potential chemical health hazards and provide information on exposure to spilled petroleum products. The report is not intended to be used as a field guide during cleanup operations following a spill. Physical hazards, such as slips, trips, falls, fire, and explosion are important, but are not discussed in this report.

Hazard identification is the first step in the process of linking scientific information about hazards (risk assessment) to the decision-making process (risk management) during which these hazards are mitigated. Figure 1-1 shows the elements of risk assessment and risk management and highlights the risk assessment process covered in this report.

Hazard identification is defined as the process of determining whether exposure to an agent can cause an increase in the incidence of a health condition (EPA, 1992). In order to identify the overall health hazards, the toxicological properties of each petroleum constituent were reviewed

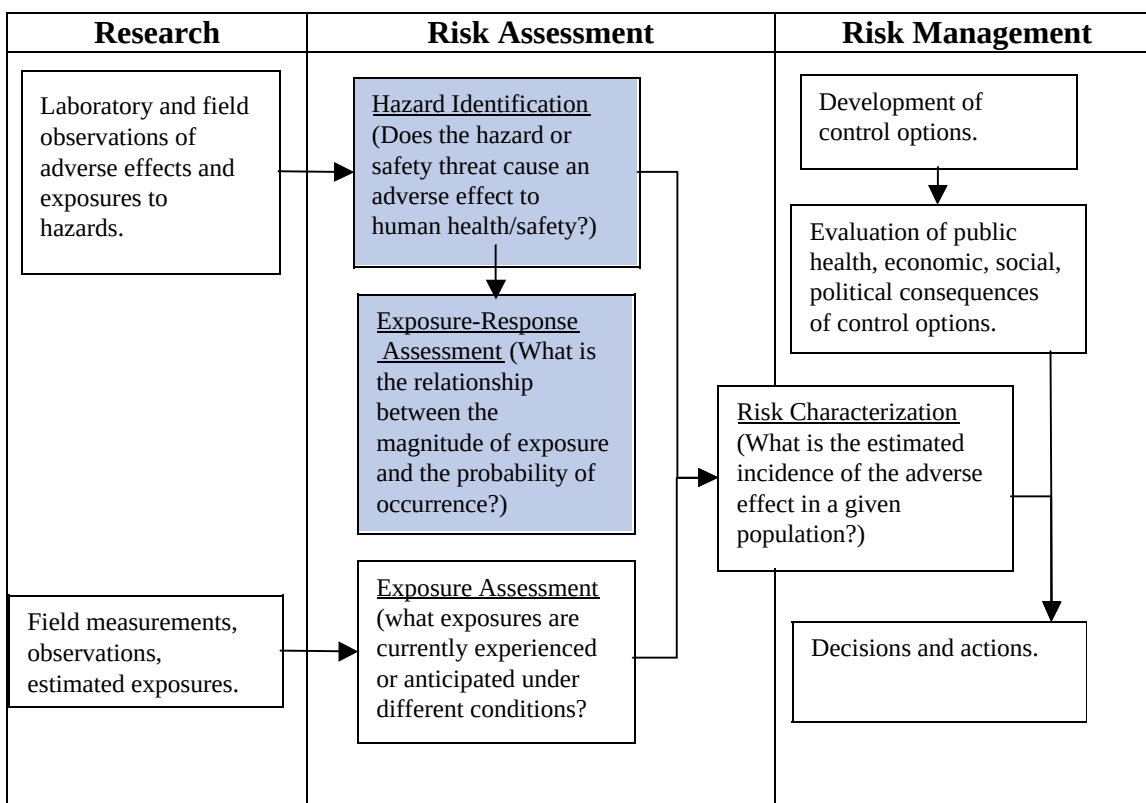


Figure 1-1. Elements of Risk Assessment and Risk Management (modified from NRC 1993).

due to the poor health hazard information available on oils as a whole. Information used to compile this summary includes toxicology databases, case histories of oil spill drills and actual incidents, as well as model data. Little relevant information on exposure to oil spill responders is available in the literature. Factors evaluated include chronic and acute toxicity by the two major routes of exposure (dermal and inhalation), and the component concentrations in the common petroleum products. These factors are summarized in Table 2-1.

The following topics are discussed:

- Identification of the most commonly spilled petroleum products;
- Review of their overall potential health hazards as well as those associated with their components of concern;
- Summarization of the relevant environmental fate of petroleum products;
- Additional considerations related to health hazard assessment.

This document is intended to provide general guidance for oil spill response planning.

Therefore, conclusions reached may not apply to all situations. Actual health concerns may vary

depending upon product composition, environmental conditions, worker training, and other factors. Where potential exposures are uncertain, air monitoring and/or conservative protective measures are recommended.

Section 2

ENVIRONMENTAL FATE AND EXPOSURE CONSIDERATIONS

This section describes the environmental fate processes and provides a brief overview of some considerations that need to be included in discussions about potential exposure. The information found in this section is based on referenced literature (Fingas, 1994, 1995; GESAMP, 1993; Koons and Jahns, 1992; Mielke, 1990; NRC, 1985, 1989). A more complete description of the environmental fate and effect processes are found in the *Fate and Environmental Effects of Oil Spills in Freshwater Environments* (API, 1999).

ENVIRONMENTAL FATE

Introduction

When oil is released into the environment, numerous processes begin to affect the environmental fate of oil components and the chemical-physical properties of the oil. The composition and physical/chemical properties of crude oil and refined products are variable; therefore, no two crude or refined oils will behave exactly the same in the environment. In addition, meteorological and oceanographic conditions will affect the movement and weathering of oil.

Spreading, drift, evaporation, dissolution, and dispersion are processes that begin immediately once oil is spilled. Figure 2-1 illustrates these processes. One process can occur at a greater relative magnitude than another process. For example, in the early phases of an oil spill, spreading occurs at a greater rate than oil drift. Dispersion of oil occurs at a greater magnitude than dissolution since only small amounts of oil components are soluble in water.

Emulsification, sedimentation, biodegradation, and photooxidation can occur within the first day of a spill, but these processes are not as predominant as spreading, evaporation, and dispersion.

Some of the fate processes, for example, evaporation, may be most relevant to human health exposure. Other processes, such as photooxidation and sedimentation, are not important determinants of human exposure. The major processes are discussed here to provide a general understanding of the environmental fate of spilled oil.