

Sunken Oil Detection and Recovery Operational Guide

API TECHNICAL REPORT 1154-2
FIRST EDITION, FEBRUARY 2016



AMERICAN PETROLEUM INSTITUTE

Special Notes

API publications necessarily address problems of a general nature. With respect to particular circumstances, local, state, and federal laws and regulations should be reviewed.

Neither API nor any of API's employees, subcontractors, consultants, committees, or other assignees make any warranty or representation, either express or implied, with respect to the accuracy, completeness, or usefulness of the information contained herein, or assume any liability or responsibility for any use, or the results of such use, of any information or process disclosed in this publication. Neither API nor any of API's employees, subcontractors, consultants, or other assignees represent that use of this publication would not infringe upon privately owned rights.

API publications may be used by anyone desiring to do so. Every effort has been made by the Institute to assure the accuracy and reliability of the data contained in them; however, the Institute makes no representation, warranty, or guarantee in connection with this publication and hereby expressly disclaims any liability or responsibility for loss or damage resulting from its use or for the violation of any authorities having jurisdiction with which this publication may conflict.

API publications are published to facilitate the broad availability of proven, sound engineering and operating practices. These publications are not intended to obviate the need for applying sound engineering judgment regarding when and where these publications should be utilized. The formulation and publication of API publications is not intended in any way to inhibit anyone from using any other practices.

Any manufacturer marking equipment or materials in conformance with the marking requirements of an API standard is solely responsible for complying with all the applicable requirements of that standard. API does not represent, warrant, or guarantee that such products do in fact conform to the applicable API standard.

All rights reserved. No part of this work may be reproduced, translated, 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, NW, Washington, DC 20005.

Copyright © 2016 American Petroleum Institute

Foreword

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.

This document was produced under API standardization procedures that ensure appropriate notification and participation in the developmental process and is designated as an API standard. Questions concerning the interpretation of the content of this publication or comments and questions concerning the procedures under which this publication was developed should be directed in writing to the Director of Standards, American Petroleum Institute, 1220 L Street, NW, Washington, DC 20005. Requests for permission to reproduce or translate all or any part of the material published herein should also be addressed to the director.

Suggested revisions are invited and should be submitted to the Standards Department, API, 1220 L Street, NW, Washington, DC 20005, standards@api.org.

Contents

	Page
1 Scope	1
1.1 Introduction and How to Use This Guide	1
1.2 Section Descriptions	1
2 Determine the Potential for the Oil to Sink Under the Spill Conditions	2
3 Select Sunken Oil Detection, Delineation, and Characterization Techniques	4
4 Determine if There are Feasible Sunken Oil Containment Techniques	13
5 Select Sunken Oil Recovery Techniques	14
6 Waste Stream Management	23
7 Safety Considerations	24

Figures

1 Relationship Between Density and API Gravity and Water Salinity	3
2 Conditions by Which Oils Can Sink Based on the Density of the Oil Relative to the Receiving Water, Turbulence, Currents, and Sediment Interaction	3

Tables

1 Matrix to Evaluate Techniques for Detection, Delineation, and Characterization of Sunken Oil	5
2 Advantages and Disadvantages of Sunken Oil Detection, Delineation, and Characterization Technologies	6
3 Summary of Sunken Oil Detection Technologies	9
4 Advantages and Disadvantages of Sunken Oil Containment Technologies	13
5 Matrix to Evaluate Techniques for Sunken Oil Recovery	15
6 Advantages and Disadvantages of Sunken Oil Recovery Technologies	16
7 Summary of Sunken Oil Recovery Technologies	19
8 Options for Treatment of Waste Streams from Sunken Oil Recovery Operations	23

Sunken Oil Detection and Recovery Operational Guide

1 Scope

1.1 Introduction and How to Use This Guide

This Operational Guide is a companion document to the technical report, *Sunken Oil Detection and Recovery*, which identifies and documents current best practices and alternative technologies possessing the potential to more effectively detect, contain, and recover sunken oil, defined as the accumulation of bulk oil on the bottom of a water body. The technical report includes summaries and lessons learned for 36 case studies of oil spills where a significant amount of the oil sank. For each technology, it includes a detailed description of the method, advantages and disadvantages, and summary tables—the kinds of information needed to select the most effective approaches to sunken oil detection and recovery. Please refer to the technical report for supporting information not in this guide.

Most oil spill response strategies, tactics, and equipment are based on the simple principle that oil floats. However, oil does not always float. Sometimes it suspends in the water column; sometimes it sinks to the bottom of the water body. Sometimes it does all three: floats, suspends, and sinks. Furthermore, oil that has sunk to the bottom can become re-suspended and spread by currents. Terminology to describe these various behaviors can be confusing; thus, in this guide, the following terminology is used.

- **Floating oil**—Spilled oil that is on the surface of the water.
- **Submerged oil**—Spilled oil that is in the water column, below the water surface, including oil that is in temporary suspension due to turbulence and will refloat or sink in the absence of that turbulence.
- **Sunken oil**—Spilled oil that is on the bottom of the water body.

This guide addresses only sunken oil.

1.2 Section Descriptions

There are six subsequent sections to this guide.

- **Section 2: Determine the Potential for the Oil to Sink under the Spill Conditions**

This section provides guidance on when to expect that an oil may sink, either initially or later due to processes such as weathering and sediment interactions. It includes a chart to help determine if an oil can sink initially based on its density or API gravity and the salinity of the receiving water. It also includes a chart that shows how turbulence and sediment interaction can cause a floating oil to submerge or sink over time.

- **Section 3: Select Sunken Oil Detection, Delineation, and Characterization Techniques**

This section includes a checklist of the types of information you will need about the oil and spill conditions to start evaluating which sunken oil detection options may be effective for the spill. There is a list of action items to guide the development and approval of a sunken oil detection plan. It also includes tabular summaries of the advantages and limitations of possible options, along with a matrix to guide selection of the best combination of options.

It is important to note that oftentimes multiple detection, delineation, and characterization methods should be used, in combination and/or in sequence. All remote detection methods require ground truthing or need bottom sampling to determine the oil thickness on the bottom or determine the oil's viscosity and thus pumpability.

— Section 4: Determine if there are Feasible Sunken Oil Containment Techniques

This section notes that containment of sunken oil may not always be feasible. It includes summaries of the advantages and limitations of possible options under mostly low-flow conditions.

— Section 5: Select Sunken Oil Recovery Techniques

This section includes a checklist of the types of information you will need about the oil and spill conditions to start evaluating which sunken oil recovery techniques may be effective for the spill. There is a list of action items to guide the development and approval of a sunken oil recovery plan. It also includes tabular summaries of the advantages and limitations of possible recovery techniques, along with a matrix to guide selection of the best combination of techniques.

— Section 6: Waste Stream Management

Because waste generation during sunken oil recovery operations is a very important consideration in both selection of the removal method and the types of waste stream treatment methods to be implemented, this section provides guidance on best practices for handling the oil, liquids, and solids generated during a response.

— Section 7: Safety Considerations

Safety is of paramount importance during all phases of sunken oil detection and recovery, as it is during any response. Therefore, this section includes safety considerations throughout the response. It also includes a checklist of the issues to consider when developing a plan to conduct sunken oil detection and recovery operations, including:

- general safety;
- equipment mobilization and heavy lift operations;
- hydraulic submersible pumps and transfer operations;
- diving operations.

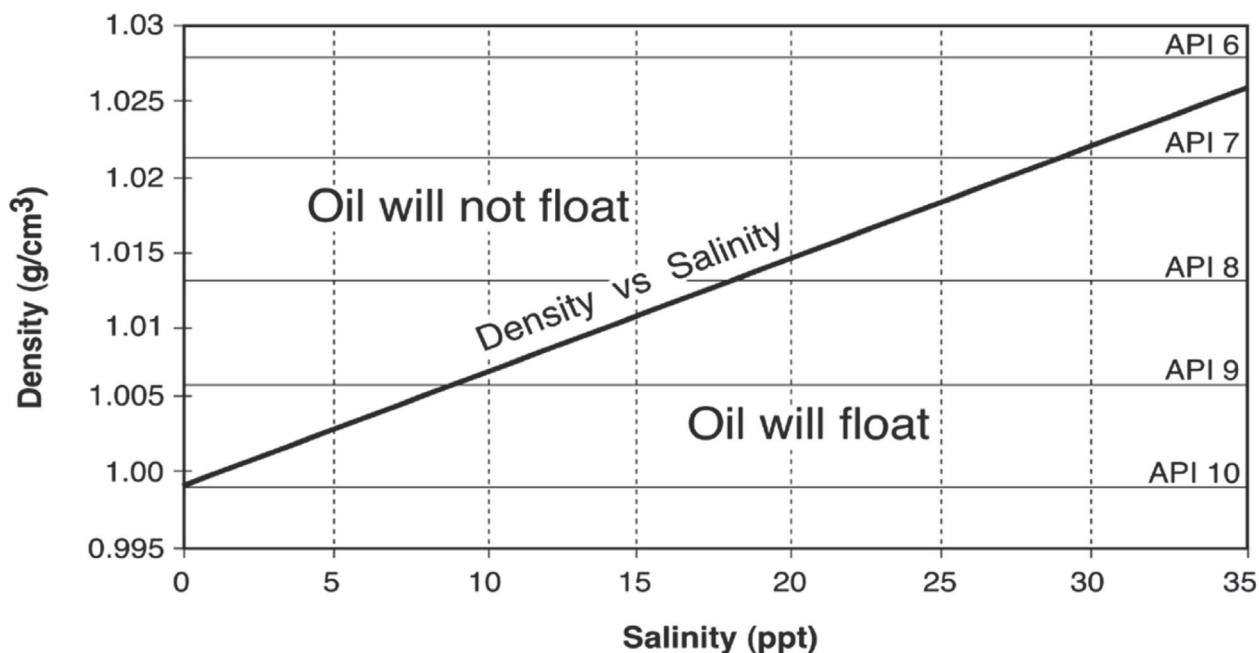
2 Determine the Potential for the Oil to Sink Under the Spill Conditions

Key points include the following.

- The API gravity or density of the oil relative to that of the receiving water will determine if the oil will sink initially after release to a water body.
- Over time, weathering or interaction with sediment can cause a floating oil to sink.
- Floating oils that may sink are generally very heavy crude oil, heavy fuel oils, or diluted bitumen products.

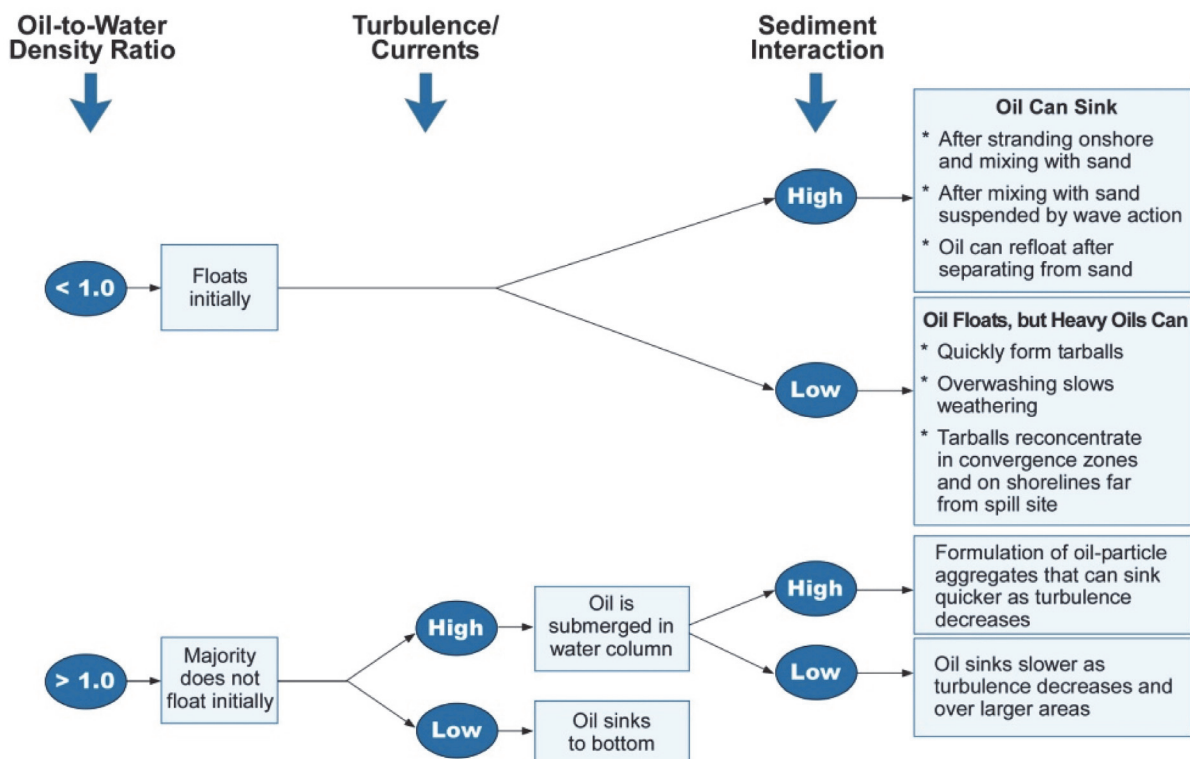
Determine the potential for the spilled oil to sink initially.

- Determine the API or density of the fresh oil and use Figure 1 and Figure 2 to determine if it will sink initially in the receiving water.
- In freshwater, oils with an API of less than 10 or a density of greater than 1.0 g/cm³ will sink if the currents are weak or turbulence is low.



NOTE Oils with values below the line will float initially; oils with values above the line will not float initially (modified after NRC, 1999).

Figure 1—Relationship Between Density and API Gravity and Water Salinity



NOTE Modified after NRC, 1999.

Figure 2—Conditions by Which Oils Can Sink Based on the Density of the Oil Relative to the Receiving Water, Turbulence, Currents, and Sediment Interaction

- In seawater, oils with an API of less than ~6.5 or a density of greater than 1.03 g/cm³ will sink if the currents are weak or the turbulence is low.
- In estuarine waters, be aware that the oil might be suspended in the water column in the freshwater part of the estuary or river, then refloat once it reaches the higher salinity water closer to the mouth of the estuary.
- Conversely, oil that floats or is submerged in estuarine waters may become submerged or sink if transported into less dense freshwater.
- If the currents or turbulence are strong, oils heavier than the receiving water will become suspended in the water column and only sink in low-flow areas downcurrent of the release. These low-flow and low-energy areas should be targets for searching for sunken oil.

Determine the potential for the spilled oil to sink over time.

- Experience has shown that oils that initially float can sink after mixing with sediment. This can occur by two pathways.
 - Floating oil that mixes with sediment after being stranded on a beach can be reworked and moved seaward by wave action to sink in the adjacent nearshore waters.
 - Floating oil can mix with sand in the surf zone and sink, without ever stranding onshore.
- Some oils are lighter than water initially but become close to or even heavier than the density of freshwater once the lighter fractions are lost by evaporation. These oils can sink as either bulk oil or oil-particle aggregates on the bottom of the water body.
- Highly viscous oils can have an increased risk of sinking over time.
 - They can entrain a lot of free water, which can increase their density.
 - They tend to be stickier, which can increase the amount of sediment uptake if stranded on the shoreline or mixed with sediments in the water column, which can increase their density.

3 Select Sunken Oil Detection, Delineation, and Characterization Techniques

Key points include the following.

- Stand up a Sunken Oil Detection, Delineation, and Characterization Group responsible for methods evaluation as soon as it is determined that there is a risk of oil sinking.
- Start mobilizing equipment as soon as possible.
- Recovery should be closely coupled with detection because sunken oil can quickly become remobilized, reducing the overall effectiveness of the response. Thus, evaluation of recovery methods should start as soon as it is confirmed that the oil may sink.
- Include equipment redundancy and alternatives to the preferred method(s) in the plan because of frequent breakdowns, changing conditions, and uncertainty in which methods are likely to be most successful.
- Refer to the matrices in Table 1 and Table 2 on the advantages and disadvantages of sunken oil detection, delineation, and characterization options and the summaries in Table 3 to guide selection of the best options for the spill conditions.

Table 1—Matrix to Evaluate Techniques for Detection, Delineation, and Characterization of Sunken Oil

Red = not likely effective; **yellow** = may be effective; **green** = most likely effective

	Sonar Systems	Camera/ Video	Acoustic Camera	Diver Observations	Towed Sorbents	Stationary Sorbents	Visual Observations	Bottom Sampling	Manual Shovel Pits	Laser Fluorosensor	Water Column Sampling
Water Depth (ft)	10 to 1000	10 to 1000	10 to 1000	5 to 190	5 to 100	5 to 100	0 to 30	0 to 1000	0 to 5	10 to 100	5 to >1000
Water Visibility											
— >30 ft	Green	Green	Green	Green	Green	Green	Green	Green	Red	Green	Green
— 5 to 30 ft	Green	Yellow	Green	Green	Green	Green	Yellow	Green	Red	Green	Green
— <5 ft	Green	Red	Green	Yellow	Green	Green	Red	Green	Green	Yellow	Yellow
Availability	Green	Green	Green	Green	Green	Green	Green	Green	Green	Yellow	Yellow
Substrate Type											
— Sand	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green
— Silty Sand	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green
— Mud	Green	Green	Green	Green	Green	Green	Yellow	Green	Yellow	Green	Green
Bottom Obstruction	Green	Green	Green	Yellow	Yellow	Green	Green	Green	Red	Green	Green
Oil Patch Size											
— <0.1 ft ²	Red	Green	Yellow	Green	Yellow	Yellow	Yellow	Red	Yellow	Green	Yellow
— 0.1 to 1 ft ²	Red	Green	Green	Green	Yellow	Yellow	Green	Red	Yellow	Green	Yellow
— >1 to 10 ft ²	Yellow	Green	Green	Green	Green	Yellow	Green	Green	Green	Green	Yellow
— >10 ft ²	Green	Green	Green	Green	Green	Yellow	Green	Green	Green	Green	Yellow
Oil Thickness	Yellow	Yellow	Red	Green	Yellow	Red	Yellow	Green	Green	Red	Red
Buried Oil	Yellow	Red	Red	Yellow	Yellow	Red	Red	Green	Green	Red	Yellow
Sensitive Habitat	Green	Green	Green	Green	Red	Green	Green	Yellow	Yellow	Green	Green
False Positives	Yellow	Green	Green	Green	Green	Green	Yellow	Green	Green	Green	Green
Coverage Rate	Green	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow
Data Turnaround	Green	Yellow	Yellow	Green	Yellow	Yellow	Green	Yellow	Green	Yellow	Yellow