# CSI New London

## *U.S. Coast Guard forensic oil spill analysis.*

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A casual perusal of the prime time television schedule quickly reveals that crime scene investigations and forensic evidence evaluation are very popular themes for viewers. Often, the storyline involves a careful and perceptive investigation at the scene of the crime where investigators collect and catalog various items of evidence. Back at the crime lab, high-tech analytical instruments quickly identify the source of the trace substance, or a DNA analysis identifies the perpetrator.

In the real world, U.S. Coast Guard pollution investigators frequently respond to "mystery spills" (oil in the environment from no obvious source) to protect the environment from further harm and to identify the source of the spilled oil. Their physical investigation of the scene is crucial to solving the case. Investigators obtain samples of the spill as well as samples from potential sources, which then undergo forensic chemical analysis to identify the responsible party.

Sometimes the pollution investigation involves an identifiable source. For many months following the *Deepwater Horizon* explosion and fire, millions of barrels of crude oil bubbled up from the wellhead a mile below the surface.[1] As the world watched video coverage of the escaping oil and gas, the U.S. Coast Guard oversaw a great effort to stop the release, contain the spilled oil, and minimize the environmental consequences. During and after the spill, National Oceanographic and Atmospheric Agency personnel, along with Coast Guard pollution investigators, collected oil samples for forensic analysis from shorelines and marshes as well as from impacted wildlife.

**Solving the Mystery of "Mystery Spills"**

The Marine Safety Laboratory (MSL) is the Coast Guard's forensic laboratory for oil spill source identification, or "oil fingerprinting," a term adopted in

### The Marine Safety Lab

**The Marine Safety Lab provides:**

- **consultation with field investigators, district offices, hearing officers, as well as National Pollution Funds Center, Department of Justice, and other federal agency personnel concerning the oil identification system and MSL analysis reports;**
- **expert opinions and testimony at legal proceedings;**
- **a system of quality controls to assure the integrity of the Oil Identification System;**
- **evaluation of new methods and advancements in technology that may increase the accuracy, reliability, and efficiency of the Oil Identification System;**
- **long-term secure storage of oil samples (evidence) that MSL has received from field units in support of oil pollution cases.**

# Analytical Techniques

### Gas Chromatography

Gas chromatography separates the components of oil, primarily on the basis of their boiling points. The separation is carried out under controlled conditions such that the same component will be eluted (removed by dissolving) from the gas chromatographic column at the same relative time for all samples.

The separated components are sensed by a flame ionization detector and simultaneously recorded electronically. Interpretation of evaporative weathering is relatively straightforward, because it affects components in the same sequence as they are displayed graphically.

### Gas Chromatography-Mass Spectrometry

Gas chromatography-mass spectrometry uses a mass selective detector to continuously collect the mass spectrum for the components eluting from the gas chromatograph.

The mass spectrum, reflecting the ion fragments present, can be used to conclusively identify individual components. For oil identification, selected target ions representing biomarkers in the oil are selected. These biomarkers are components unique to petroleum oils; their ratios are used to characterize individual oils.

Because some are highly resistant to biodegradation and other types of weathering, severely weathered oils that cannot be identified by other means can often be matched through this technique.

### Fourier Transform Infrared Spectroscopy

Fourier transform infrared spectroscopy uses the absorption of infrared energy over a spectral region that corresponds to the bond stretches and vibrations of the molecules that form the oil.

A number of absorptions are common to all petroleum oils, which allows the analyst to identify the sample as a petroleum product. Other absorptions are used for uniquely identifying specific oil samples.

Comparison of the infrared spectra, taking into account weathering differences, is sometimes used to eliminate dissimilar sources from further analysis. Fourier transform infrared spectroscopy is particularly sensitive to the presence of water and can be used to screen samples to reduce prep time, especially in cases containing a very large number of samples from cargo or fuel tanks that are likely to be free of water.

the mid-1970s when the Coast Guard Research and Development Center developed the oil spill identification methodology.[2] The primary mission of MSL is to conduct the chemical analyses necessary to identify the source of an oil spill in conjunction with Coast Guard field investigations.

The Marine Safety Lab supports pollution investigators and various federal, state, and local agencies by providing forensic analysis of spilled oil samples and suspected source samples. Additionally, MSL works closely with the National Pollution Funds Center and the Department of Justice to prosecute responsible parties. The Marine Safety Laboratory's analytical evidence provides law enforcement and cost recovery benefits, as MSL's forensic chemist provides expert witness testimony for hearings and court proceedings, as necessary.

The lab uses several complementary chemical tests that exploit the unique intrinsic properties of petroleum oil and make it possible to match spilled oil with its chemical source. MSL provides the means to fix oil pollution responsibility, assess penalties, and help recover federal pollution cleanup funds expended during an incident. The lab's work also serves as a deterrent to deliberate oil pollution discharges and encourages reporting and acceptance of responsibility for accidental spills.

### Oil Spill Identification Methodology

The Oil Identification System (OIS) uses the unique, intrinsic properties of petroleum oil that make it possible to match spilled oil to the correct chemical source. The system supports multiple analytical methods. Of the original four techniques developed and evaluated for the OIS, two of them used today have undergone marked technological refinements: gas chromatography and infrared spectroscopy.

Additionally, gas chromatography-mass spectrometry has been added as the most powerful analytical technique available for oil fingerprinting. As a consequence of more definitive results made possible by these improved methods, the lab no longer uses the other two original techniques: fluorescence spectroscopy and thin layer chromatography.

These modern analytical methods measure different chemical properties of an oil sample. If two oils are chemically similar, they are said to derive from a common source. In nearly every case, oils from other possible sources are simultaneously eliminated from consideration as the pollutant source because they are chemically different as determined by the test methods.

### How Is a Typical Oil Spill Case Processed?

When a pollution incident occurs, a local Coast Guard unit will collect samples of the spill and obtain samples from possible sources (vessels and shore facilities) in accordance with MSL's Sample Handling and Transmittal Guide.[3] Most oil spill cases arrive at the lab by overnight shipping.

The sealed boxes are opened and all samples are accounted for by checking them against the enclosed chain of custody. Any discrepancies are noted and will be resolved by MSL personnel through consultation with the investigating unit. Also enclosed with the samples is a letter of request. This document tells personnel what the investigators need the lab to do

A Marine Safety Lab forensic chemist and technician work to extract a sample from a hose suspected of being used to bypass an oily water separator. USCG photo.

# The Marine Safety Lab

## History

The Federal Water Pollution Control Amendments of 1972 assigned general responsibilities to the Coast Guard for the protection of the marine environment, including enforcement of the nation's antipollution discharge laws and regulations.

To carry out these responsibilities, in 1973 the Coast Guard Research and Development (R&D) Center began to develop a system to identify pollutant sources. In four years, many analytical tests and procedures were evaluated for their ability to distinguish all types of petroleum oil. In 1977, the R&D Center published its final report detailing the Coast Guard's Oil Spill Identification System. The Central Oil Identification Laboratory (COIL), established in November 1977, applied the system and was located within the R&D Center facilities in Groton, Conn.

## Legal Precedent

One of the first steps for COIL and the new Oil Identification System was obtaining legal precedent for its "oil fingerprinting" technique. This occurred in December 1978 at a federal criminal jury trial, under the Federal Water Pollution Control Act, involving spilled oil. In *U.S. v. Distler,* Judge Charles M. Allen ruled that "chemical evidence" would be admissible, thereby establishing the necessary legal precedent.[1]

In 1979, administrative control of the Central Oil Identification Laboratory transferred to the Coast Guard Oceanographic Unit in Washington, D.C. However, COIL operations under the Oceanographic Unit were to be short lived when the "O Unit" closed in April 1982. At that time, COIL became a branch of the Port and Environmental Safety Division, Office of Marine Environment and Systems.

The Central Oil Identification Laboratory then moved to the Avery Point campus of the University of Connecticut in Groton, Conn., in 1986. In 1988, COIL and the Marine Fire and Safety Research Staff merged to form the Coast Guard Marine Safety Laboratories. During 1991, control of the Marine Fire and Safety Research program returned to the Coast Guard R&D Center and COIL became the Marine Safety Laboratory.

## The Evolution

As part of the Coast Guard's streamlining initiatives in 1996, the laboratory's top leadership position was converted from a commanding officer to a Coast Guard civilian supervisory chemist with the title of manager.

In January 2006, as part of the Coast Guard's continued modernization efforts, MSL divested as a subunit of the National Maritime Center and became a headquarters unit under the Coast Guard's Office of Investigations and Analysis. Shortly thereafter, the Marine Safety Lab underwent an A-76 streamlined competition study. MSL's proposed most efficient organization won the competitive bid and began its first year of contract performance on January 31, 2007.

In February 2009, the Marine Safety Lab, along with the R&D Center and International Ice Patrol, relocated from Avery Point, Groton, to the Fort Trumbull area in New London.

**Endnote:**

1. United States v. Distler, 9 ENVTL. L. REP. (ENVTL. L. INST.) 20,700 (W.D. Ky. 1979).

with the samples (compare or ID only) and in what time frame (regular, priority, or RUSH).

After the samples are checked in on paper and electronically, staffers move to the sample preparation stage. While most of us think of oil as an environmental pollutant, from our perspective, the environment is polluting our oil sample. At the prep station all the water, sand, seaweed, and such is removed, leaving a "neat" (unadulterated) oil sample. The neat is then diluted with cyclohexane solvent for injection into the gas chromatograph (GC). It takes about an hour for the GC to analyze each sample. Fortunately, once the prepared vials are placed into the sample tray, an automated sample handler allows the instrument to run 24/7 without an operator.

After the lab technician and the forensic chemist review the GC data, the samples are analyzed via gas chromatography-mass spectrometry, which provides even more detailed information about the composition.

Interpreting the analytical test results is usually not straightforward because of increased analytical complexity brought about by weathering or contamination of the spilled oil. "Weathering," for example, includes such processes as evaporation, dissolution, biodegradation, oxidation, and other chemical, physical, and biological environmental changes that alter the makeup of the spilled oil, significantly complicating the analyst's job.

MSL prepares a written analysis report for each case and maintains a complete case file that includes:

- the expert opinion of a trained forensic chemist;
- a forwarding letter;
- laboratory report with results and conclusions;
- sample check-in log;
- case documentation (such as the analysis request and chain of custody);
- quality assurance sheet;
- cost-recovery documentation;
- worksheets;
- the original test data.

**How Can We Improve the Process?**

MSL provides on-call assistance to Coast Guard field investigators, district personnel, and hearing officers as well as the National Pollution Funds Center, Department of Justice, and other government agencies, on all aspects of the Oil Identification System. This assistance includes:

- answering questions and explaining the significance of test results,
- evaluating test data from other laboratories,
- providing expert witness support,
- planning sampling strategies in complex cases.

An effective Oil Identification System depends upon good communication and understanding among the various users of the system and Marine Safety Lab personnel. Please give us a call. We are eager to help!

***About the author:***
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**Endnotes:**

1. *Deepwater Horizon* Oil Spill. Available at www.uscg.mil/foia/docs/DWH/BPDWH.pdf.
2. *Oil Spill Identification System.* USCG R&D Center Report No. CG-D-52-77 (NTIS #ADA044750), 1977.
3. *Sample Handling and Transmittal Guide,* Version 7.0. U. S. Coast Guard Marine Safety Laboratory, October 2010.