

Observation and Quantification of Spills

This ITAC paper is intended to provide an overview of the issues and actions which need to be considered by those integrating observation and quantification of spills into contingency plans or undertaking such activities during an incident.

This document highlights some of the considerations which must be understood before assigning personnel to a spill observation role. It further discusses the issues regarding quantification and the use of the information gathered for purposes of response planning and how the information may be misperceived by external parties.

This document is not a field guide on aerial observation techniques but does provide information on other reference sources including ITAC member organisations where such information and training material can be found.

Observation and Quantification

When oil spills occur, one of the first and most frequently asked questions from authorities, public and media will be how much has been spilled and how much has been recovered. It is uncommon for the exact quantity spilled to be known at the outset and determination can be time consuming. In most cases this quantification can only be done accurately within the post incident investigations. The fact that the actual quantity spilled cannot easily be determined is an important point to make to public and media but one that is often omitted in press releases.

Contingency plans ideally will use a tiered approach to match appropriate combating resources to the potential impacts of a spill. The spilled volume is one of the factors which should be considered along with the location, oil type, sensitivity and potential impacts in assessing the tier definitions. Whilst quantification methods discussed in this paper are unlikely to provide a definitive answer on quantity, there should be sufficient basis upon which to determine whether an incident is classified as requiring a Tier 1, Tier 2 or Tier 3 response.

The authorities and those managing the response will still find it useful to obtain a rapid assessment of the locations, estimated quantities, physical state and behaviour of the spilled product. In particular this will assist in determining if the scale of resources mobilised is sufficient. More importantly, it will enable identification and prioritisation of oil concentrations most likely to impact on sensitive resources.

The Industry Technical Advisory Committee (ITAC) is a forum for information exchange between experts within the global oil spill response community.

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Contact:

Web: www.industry-tac.org
Email: info@industry-tac.org
Tel: +44 (0)23 8033 1551
Fax: +44 (0)23 8033 1972
Oil Spill Response, Lower William Street, Southampton, SO14 5QE, UK

Planning for Observation and Quantification

Pre-planning is essential prior to undertaking any observations for quantification otherwise disagreement, misdirection and confusion may ensue. Some important criteria to consider in response planning include:

- The Observation Platform
- Observer Selection
- Safety
- Quantification Tools
- Recording and Reporting



The Observation Platform: Oil is best observed from above (e.g. an aircraft or satellite). The choice of observation platform is often determined by the location of the incident and available resources, but altitude is a benefit in all forms of observation of oil on water. Not only does it allow a greater area to be observed, it also allows the apparent colour differentiation between different thicknesses of oil to be observed more easily which can assist in quantification.

Fixed wing aircraft or helicopters provide the best observation platforms due to the combination of altitude for observations, rapid transit times to affected areas and ability to search large areas in a relatively short time. The latter feature is particularly important where exact location of oil is unknown or a spill only suspected. Where there is a choice of aircraft design, better visibility is afforded by high-mounted wing types. Over near-shore waters the flexibility of helicopters is an advantage, for instance in surveying an intricate coastline with cliffs, coves and islands.

Where vessels are planned to be used (for example when observing from fixed installations) or landward locations, observations should be made from the highest point, taking account of the need to record and communicate information on what has been observed.

Observer Selection: The observer should be a trained and experienced person. In order that the observations and quantification are accepted by all parties, the observer would ideally be mutually agreed. Alternatively a joint survey can be beneficial in providing a consensus report agreed by two or more individual observers representing different stakeholders.

Oil, once spilled, is subject to continuous movement and changes in appearance over time, and separate surveys may provide dramatically different results. Joint surveys can help to overcome such complications by supporting consensus agreement on what has been observed. Joint surveys can also help to moderate the issue of differences in training and experience between observing parties.

It is not uncommon for the initial and subsequent observation to be undertaken by different people or groups. Care should be taken in comparing the observations as personnel may have different levels of training and later observations may be made from a different observation platform. Changes in background light conditions, cloud base and degree of cloud cover can also influence the individual perception of the oil. It is also often the case that observation and quantification flights are diverted in larger incidents into situation familiarisation flights, where arriving personnel want to quickly familiarise themselves with the incident location and situation. While these flights may be beneficial, they should not be allowed to divert or displace the observer team from their key role.

In some locations specialised planes provided by governments or industry may exist. These planes may be fitted with remote sensing equipment, (IR, FLIR, UV, SLAR, or possibly microwave sensors), and

have trained and experienced observers and pilots which enable them to provide more accurate and timely reports.

The most commonly employed sensors include Side-Looking Airborne Radar (SLAR), downward looking thermal infra-red (IR) and ultra-violet (UV) detectors or imaging systems. Other systems such as Forward Looking Infra-Red (FLIR), Microwave Radiometers (MWR), Laser Fluorosensors (LF) and Compact Airborne Spectrographic Imagers (CASI) have the potential to provide additional information. Some of these sensors have the capability to produce useful imagery at night which is an important consideration, particularly during winter in high latitudes when the hours of natural daylight necessary for conventional observation, are severely limited.

The sensors work by detecting properties of the sea surface: colour, reflectance, temperature or wave attenuation which the presence of oil affects. The output of two or more of these sensors when overlaid by computer can provide detailed imagery of the surface slick dimensions and character. In addition these outputs should be supplemented by visual human eye, still camera and video observations. Unfortunately even where such instruments are available to supplement human observers, results can be misleading due to the assumptions which are made in the calibration of the instruments. Therefore care is required in the use and release of information obtained and its interpretation. The latter comments apply equally to satellite images which can easily detect surface effects other than those caused by the oil such as wind shadow, tidal phenomena, sub-surface topographical features and weather fronts.

Safety: The safety of personnel is always paramount and any observation or quantification exercise should take account of the potential hazards. The lighter components of oils which evaporate may form a toxic or explosive gas cloud and observation should be, where possible and practical, from a safe distance upwind of the slick.

For aircraft the flight path should maintain a safe altitude perhaps 150 ft (50 metres) for detailed observation. Any smell of oil vapour should be taken as an indication that greater distance or altitude needs to be maintained. As the oil weathers, approach distances may be reduced accordingly.

The captain or pilot should always be involved in the development of the flight plan, anticipated search area, expected duration and the number of personnel that will be embarked. He will be able to advise on any restriction on routes, number of personnel and seating locations to maximise observation and recording. For example agreeing which side observations of oil will be made from, best location for photography, who will record observation data such as altitude and position and methods of communication with the pilot if items of interest are noted which need more detailed inspection.



The altitude for wide area search activities is generally determined by the prevailing visibility. For aircraft over open sea areas, in clear weather, 1000-1500 feet (300-450 metres) frequently proves to be optimal for maximising the scanned area without losing visual clarity. However, it may be necessary to drop to half this height or lower in order to confirm any sightings of floating oil or to analyse its appearance in greater detail. With helicopters, coastal flights at speed of 80-90 knots and an altitude of 400 - 500 feet (120-150 metres) are common when safe to do so. Clearance may be needed to operate in some areas

or for when aircraft change altitudes, and co-ordination with flight traffic control may be needed to avoid conflict with other aircraft that might be operating in the area.

Flight Safety: Aircraft, both fixed wing and rotary, are potentially dangerous, and personnel should be fully briefed in the correct techniques for boarding, disembarkation, evacuation (particularly in the event of an on-water ditching), and use of the in-built communications systems. Where personnel are to use communications equipment, they must be aware of the need to maintain silence during takeoff and landing when the pilot may be in communications with the control tower. Twin engine aircraft should be used for all over water operations and, where available, those fitted with supplementary flotation devices.

Quantification Tools: Quantification is not a matter of determining simply how much oil is in a given location. Quantification requires the observer to gather as much information as possible about the location, condition and possible movement of the oil. It can also help provide an assessment of the effectiveness of response measures.

Once oil has been spilled, it will become susceptible to the effects of the environment which will redistribute the oil, reduce its volume, change its characteristics, and mix it with water, sediment and debris. The volume of oil which is spilled is therefore not the same as the volume of material which may need to be recovered. Even where the quantity spilled is known with certainty, the quantity of oil that can be recovered will be less, while the quantity of total waste including incorporated water, debris, and sediment may be more. This simple fact is often omitted, or not otherwise explained, leading the public, media and authorities to believe or expect that recovery of the total volume should be possible.

Where specialised aircraft are not available, observation and quantification will rely of the human eye. Simple tools such as polarising sunglasses can assist the detection, and the area covered can be determined using known objects in the field of view as a reference, converting flight time and speed, or by use of position fixing systems such as GPS. These techniques, while helping to fix the location and area affected, cannot on their own provide an estimate of the quantity of oil.

Significant scientific effort has been focused on the issue of quantification, including the development of specialised instruments and attempts at international standardisation of colour codes (whereby the observed colour corresponds to ranges of oil thickness). A correlation between oil thickness and apparent colour / appearance of the oil has been established however although several codes have been developed / adopted, there is no agreed standard on the interpretation of observed oil colour / appearance. Additionally results are somewhat subjective as individuals may perceive colour differently and when combined with the individual's assessment of areas, percentage cover, etc., there can be significant differences of interpretation.

There are a number of guides, job aids and other reference materials which can improve the quality and repeatability of observations by providing reference photographs and other tools, but even where observers are trained on the same materials, their observations may vary. For all of these reasons it should be understood that observation of oil on the sea surface is very much an art rather than an exact science.

While it is difficult to assess accurately the quantity of oil observed at sea, due to difficulties of gauging thickness and area coverage, it is reasonable to assess the order of magnitude of the spill. This may help with planning the required scale of response effort / resources or to confirm if oil volumes are decreasing, resulting from response operations or natural processes.

The table below is one example of an oil colour interpretation code. While it will not be able to give the exact quantity of oil, it can be used by the same observer to give an indicative quantity.

Oil Appearance Code	Approximate thickness	m ³ /km ²
Oil Sheen Silver	>0.0001	0.1
Oil Sheen Iridescent (rainbow)	>0.0003	0.3
Crude and Fuel Oil Brown to Black	>0.1	100
Water-in-oil Emulsions Brown/Orange	>1	1000



The Bonn Agreement Oil Appearance Code is designed for use by trained observers and is now being used by many authorities primarily to assist with evidence needed for prosecution of illegal discharges. This is a more recent development and is based on a comprehensive scientific study. It offers a range of volumes for a given area of uniform appearance whereby the maximum end of each range can be used for response level determination whilst the minimum figure may be used for legal purposes. Acceptance of this code, whilst not universal, is increasing and a new IMO/IPIECA guide currently being developed (2009) will further extend its use and acceptance. It is more important for consistency and determination of what is happening to the oil that the same code is used for each observation and by all observers for any given event.

Recording and Reporting: Making observation, quantifying how much oil is present, and noting its state at any location is only useful if that information can be transmitted in a timely manner and useable format to those directing the incident response.

In planning the observation and quantification of oil, a system of recording must be identified and agreed upon. Numerous organisations have produced forms and aids which can be adopted or modified to suit most locations. Details of some are given at the end of this document.

After the initial spill reports there may be a temptation to migrate to new, more detailed forms of recording and reporting. Observation and quantification are imperfect, and it is by comparison with records from previous flights that changes and trends are identified. When the format is changed, these trends may be missed or lost in the mass of new data.

The main features that should be recorded are location, areas covered, apparent colour and any observations on the apparent state of the oil (dispersing, emulsifying, fragmenting, over washed or submerging). Working sketches and annotations will need to be developed either by hand or with the aid of a computer to produce a final map for presentation. Maps allow much more rapid assimilation of information for strategic planning while written reports can be useful at the tactical level.

Photographs can also provide a useful record and assist others in understanding terms used by the observers. Where capacity permits, photography (either still or video) should be undertaken by persons other than the principal observer. When the observer is using the camera, a second person should be employed to log the position and description of the item being photographed. Whilst a compact high-resolution digital camera can give good results which can be quickly downloaded, a conventional film camera may be preferred for legal evidence purposes, if this is a requirement. Although there can be a temptation on joint flights to have multiple cameras, this can be counterproductive and a pooling of all images from a single camera agreed in advance is a better solution. Whenever possible, features such as ships and the coastline should be included to give an idea of scale. Dedicated remote sensing

aircraft often have built-in downward looking cameras linked with a GPS to assign accurate geographic co-ordinates.



Summary

It is only where a combination of a good observation platform, a skilled observer, safe operations, quantification tools, and a sound recording and reporting system are employed that observation and quantification can be truly useful to the spill response. In many cases dedicated reconnaissance systems will not be available and more rudimentary tools and practices will need to be employed. These can be effective but only if guidance and training have been given and the issues of observation, quantification and interpretation of the information have been considered.

Training for observers should be conducted in advance and preferably in conjunction with the aircraft, pilots and all potential involved parties. These training sessions can allow the colour codes, recording and reporting mechanisms and other factors to be tested, ensuring that in an incident, reliable, agreed, consistent information can be provided.

Finally it is important for those involved in an incident to note and communicate to the media and public that observation of oil is an art and that quantities published are best estimates and not confirmed facts.

Useful References

- Bonn Agreement:, "Aerial surveillance" and "Meetings and documents" sections. <http://www.bonnagreement.org>
- Centre of Documentation, Research and Experimentation on Accidental Water Pollution (*Cedre*):, "Discharge at sea" section. <http://www.cedre.fr>
- Helsinki Commission, aerial surveillance: http://www.helcom.fi/shipping/waste/en_GB/surveillance.
- International Tanker Owners Pollution Federation (ITOPF): <http://www.itopf.com/aerial.html>.
- National Oceanic and Atmospheric Administration (United States) : documents "Open-Water Oil Identification Job Aid for Aerial Observation" Job Aid. <http://www.noaa.gov>,
- IMO Guidance Document on Identification and Observation of Spilled Oil [under development]