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# Standard Guide for Selection and Operation of Vessel-mounted Camera Systems[1]

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## 1. Scope

1.1 This guide provides information and criteria for the selection of camera remote sensing systems that are vessel-mounted for the detection of oil on water.

1.2 This guide applies to the detection of oil-on-water involving cameras of IR, visible, ultra-violet, or night vision types.

1.3 The context of camera use is addressed to the extent it has a bearing on their selection and utility for certain missions or objectives.

1.4 This guide is generally applicable to all types of crude oils and most petroleum products, under a variety of marine or fresh water situations.

1.5 Many camera technologies exhibit limitations with respect to discriminating between the target substances under certain states of weathering, lighting, wind and sea, or various camera settings.

1.6 General remote sensing systems are used to detect and delineate the overall slick. Vessel-mounted systems are used only to provide a tactical image in front of the recovery vessel.

1.7 The values stated in SI units are to be regarded as standard. No other units of measurement are included in this standard.

1.8 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

## 2. Referenced Documents

2.1 *ASTM Standards:*[2]

F2327 Guide for Selection of Airborne Remote Sensing Systems for Detection and Monitoring of Oil on Water

## 3. Significance and Use

3.1 The contributions of an effective vessel-mounted camera system:

3.1.1 Provide a tactical image of the portion of spill in front of the vessel upon which the system is mounted,

3.1.2 Assist in detection of slicks when they are not observable by persons operating at, or near, the water's surface or at night,

3.1.3 Provide assistance in judging whether these are sheens or slicks containing the most oil,

3.1.4 Provide input for the operational deployment of equipment,

3.1.5 Extend the hours of clean-up operations to include darkness and poor visibility,

3.1.6 Identify oceanographic and geographic features toward which the oil may migrate,

3.1.7 Locate reported oil-on-water, and

3.1.8 Guidance for operational crews to the slick(s).

## 4. Overview of Remote Sensing Equipment Capabilities and Limitations

4.1 The capability of camera equipment is determined by the physical and chemical properties of the atmosphere, the water, and the target oil. There may be variations in the degree of sophistication, sensitivity and spatial resolution of sensors using the same portion of the electromagnetic spectrum and detector technology. Sensors within a given class tend to have the same general capabilities and typically suffer from the same limitations (see Guide F2327).

4.2 Combinations of camera types may offer broader spectral coverage that permit better probability of detection, better discrimination, and effective operation over a broader range of weather and lighting conditions. Certain combinations, or sensor suites, are well documented, and their use is particularly suited to oil spill response missions.

4.3 Camera performance can be enhanced by a variety of real-, near real-time or post processing techniques applied to

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[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

the acquired data or imagery. Furthermore, image or data fusion can greatly enhance the utility of the camera output or product.

4.4 In a deployment of camera systems, it is likely that the source, general location and type of oil have been reported in advance of the launch of the vessel upon which the camera system is mounted. The planning for spills in different situation influences the selection of cameras.

4.5 Vessel-mounted cameras can provide tactical imagery, such as to determine the response vessel maneuvers to enhance the oil encounter rates during daytime and nighttime.

4.6 In rough sea conditions, some form of camera stabilization may be needed to produce a useful image.

4.7 No sensor is currently available to give information on actual oil thickness. Only relative thickness information, thick or thin, can be derived from an infrared camera.

4.8 Table 1 lists cameras based upon their mode of operation. Summary information on their positive features and limitations is presented.

4.9 Table 2 presents a summary of key attributes which generally influence the selection of cameras.

## 5. Summary

5.1 The information presented in this guide should be considered a starting point for camera selection. In addition to the context of use and the attributes of the various types of sensors. Both camera technology, and image and data analysis capabilities are evolving rapidly. Some equipment is not commercially-available.

5.2 After selecting the camera, one must select the correct mounting angle and position. A nomogram is presented in Table 3 to assist in mounting the camera and selecting view angles. Cameras for surveillance applications are suited to oil spill vessel applications as they are available with remote angle and pan controls as well as narrow fields of view (vertical and horizontal view angles). Fig. 1 shows the essential cross section of a camera mount.

5.2.1 It is important then to purchase a camera with the vertical and horizontal view angles that will permit the vessel to look forward sufficiently to enable steering into the slick. It is important that the camera have a good view of the slick and of the boom, if used, where the skimmer is positioned. Calculations were made on optimal angles, etc. and are presented in Table 3.

5.3 *Setting the Camera Angle*—The camera is best set at Brewster's angle, which is about 53° from the vertical. At Brewster's angle, reflection from the water surface is minimized. This angle however may not permit sufficient forward view for some applications. Thus an adjustable camera is desirable. See Fig. 2.

## 6. Conclusions

6.1 Vessel mounted cameras can provide useful imagery to assist in maneuvering the vessel during oil recovery to enhance oil encounter rate.

6.2 Four types of cameras are used, infrared, visible, ultraviolet and night vision. Infrared is common and can provide imagery discriminating between sheens and thicker oil. Infrared cameras are often used together with visible cameras. Ultraviolet cameras may be less useful as they highlight sunlight and other glare. Night vision cameras may enhance night recovery operations.

6.3 The height and angle mounting of the camera are important both to provide a useful image as well as to provide desired coverage of sea surface. Cameras should be mounted at or near Brewster's angle (about 53° from the vertical).

6.4 Cameras with pan, tilt, zoom capability are best for vessel-mounted applications.

## 7. Keywords

7.1 mast-mounted sensors; oil spill detection; oil spill remote sensing; ship-mounted sensors

**TABLE 1 Camera Characteristics**

| Camera/Band | Principal of Operation | Positive Features | Limitations |
|---|---|---|---|
| Visual | Operate in, and near, the (human) visible spectrum (400 to 750 nm). Using photographic films, scanners with one or more narrow band detectors or charge coupled devices (CCD) to capture an image. | Equipment is widely available, generally inexpensive, light and easily accommodated on most platforms. Imagery is in every-day use and the layman can easily relate to its content. This characteristic makes the imagery an excellent base for recording and presenting other data. | Oil is generally perceptible over the entire visible spectrum, but is not specific to an oil type. Instances of not being able to discriminate the oil from its background, or differentiate it from other substances or phenomena in or on the water's surface, lead to frequent non-detects and false detects. Night vision cameras may extend the operational window, but visual technologies are limited by available light. |
| Infrared | While the infrared (IR) spectrum ranges from 750 nm to 1 mm, the bulk of the camera systems operate in the thermal or mid-IR, 3 to 30 µm (3000 to 30 000 nm). Within this range there are two predominant sub-groups operating at 3 to 5 µm and 8 to 12 or 14 µm. The latter range offers the most useful data for oil spills. | Fresh oil shows a contrast to open water in the thermal infrared. This characteristic is not unique to hydrocarbons. Slicks thicker than about 20 to 70 µm[A] can be seen. Newer IR cameras have excellent thermal discrimination, fairly good resolution, are light-weight, have modest power demands, and typically have both digital and video outputs. | Small patches, thin, or significantly weathered oil may not be detectable. Other heterogeneities such as high amounts of seaweed or debris, oil in or on ice, oil on beaches, etc. may render the oil undetectable in the IR. There is no relationship between slick thickness and the intensity of the IR image. In the daytime thick oil is hotter than water and oil of intermediate thickness is cooler. (The cross over with water occurs when the oil is about 20 to 150 µm thick.)[B] At night this relationship reverses (unless the spill is fresh and the oil is hotter than the water when it arrives at the surface). This results in two periods per day (near sunrise and sunset) with poor discrimination. |
| Ultraviolet | Oil is highly reflective in the ultraviolet (UV–200 to 400 nm). | Very thin (<10 µm) layers of oil can be detected in the UV.[B] Thus, even sheens, can be delineated. UV cameras have fairly good resolution, are lightweight, and have minimal power demands | High UV reflectance is not unique to oil. Sun glint, biogenic and other materials and phenomena can yield strong returns in the UV. This technology is limited to available light situations and is best used in combination with other sensors, typically IR. |
| Night Vision Cameras | Low light levels are amplified and then captured on a conventional camera system. | Can provide a clean image of the targeted scene even in complete darkness. | Image is still limited as there is no unique oil signature. Extraneous light as from navigation lights may flood the image. |

[A] Fingas, M. F., and Brown, C. E., "Oil Spill Remote Sensing, A Review," Chapter 6 in Oil Spill Science and Technology, Elsevier, New York, NY, 2011, pp. 111–169,.

[B] Fingas, M., and C. Brown, "Oil Spill Remote Sensing: A Forensic Approach", Chapter 14 in Oil Spill Environmental Forensics: Fingerprinting and Source Identification, Z. Wang and S. Stout, Eds., Academic Press, Amsterdam, 2007, pp. 419–447.

**TABLE 2 Key Attributes for Camera Selection[A]**

| Camera | State of Development | Experience in Use[B] | Specific to Oil | Immunity to False Targets | Acquisition Cost Range k$ | Special Mounting Requirements |
|---|---|---|---|---|---|---|
| CCD Camera | High | High | Poor | Poor | 1 to 5 | none |
| Video—visual | High | High | Poor | Poor | 1 to 10 | none |
| IR camera (3 to 5 μm) | High | Medium | Poor | Poor | 4 to 10 | none |
| IR Camera (8 to 14μm) | Medium | Medium | Medium | Medium | 10 to 50 | none |
| UV Camera | Medium | Medium | Poor | Poor | 4 to 20 | none |

[A] Information presented in this table was adapted from: Fingas, M. F. and, Brown, C., "Oil Spill Remote Sensing: A Review," Chapter 6, in Oil Spill Science and Technology, M. Fingas, Editor, Gulf Publishing Company, NY, NY, 2011, pp. 111–169.
[B] The Experience in Use refers to the amount of historical use.

**TABLE 3 Nomogram Showing Mast Heights, Camera Angles, and Coverage**

| Camera height above water (m) | Viewing angle (a) (°) | Camera vertical view angle (b) (°) | Distance along water (m) | Camera Horizontal View Angle (c) (°) | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | Distance across water (m) | | | Area viewed on water (m$^2$) | | |
| 8 | 53 | 3 | 0.3 | 0.5 | 1.5 | 3 | 0.2 | 0.5 | 1 |
| 8 | 53 | 7.5 | 0.6 | 0.4 | 1.2 | 2.4 | 0.2 | 0.7 | 1 |
| 8 | 53 | 12.5 | 1 | 0.4 | 1.2 | 2.4 | 0.4 | 1.2 | 2 |
| 8 | 53 | 20 | 1.7 | 0.4 | 1.3 | 2.6 | 0.7 | 2.2 | 4 |
| 8 | 45 | 3 | 0.3 | 0.5 | 1.5 | 3 | 0.2 | 0.5 | 1 |
| 8 | 45 | 12.5 | 1.2 | 0.5 | 1.4 | 2.9 | 0.6 | 1.7 | 3 |
| 8 | 45 | 20 | 2 | 0.5 | 1.5 | 3 | 1 | 3 | 6 |
| 8 | 40 | 3 | 0.3 | 0.5 | 1.5 | 3 | 0.2 | 0.5 | 1 |
| 8 | 40 | 12.5 | 1.3 | 0.5 | 1.6 | 3.1 | 0.7 | 2.1 | 4 |
| 8 | 40 | 20 | 2.1 | 0.5 | 1.6 | 3.2 | 1.1 | 3.4 | 7 |
| 12 | 53 | 3 | 0.4 | 0.7 | 2 | 4 | 0.3 | 0.8 | 2 |
| 12 | 53 | 10 | 1.3 | 0.7 | 2 | 3.9 | 0.9 | 2.6 | 5 |
| 12 | 53 | 20 | 2.5 | 0.6 | 1.9 | 3.8 | 1.5 | 4.8 | 10 |
| 12 | 45 | 3 | 0.4 | 0.7 | 2 | 4 | 0.3 | 0.8 | 2 |
| 12 | 45 | 10 | 1.5 | 0.8 | 2.3 | 4.5 | 1.2 | 3.5 | 7 |
| 12 | 45 | 20 | 2.9 | 0.7 | 2.2 | 4.4 | 2 | 6.4 | 13 |
| 12 | 40 | 3 | 0.5 | 0.8 | 2.5 | 5 | 0.4 | 1.3 | 3 |
| 12 | 40 | 10 | 1.6 | 0.8 | 2.4 | 4.8 | 1.28 | 3.8 | 8 |
| 12 | 40 | 20 | 3.2 | 0.8 | 2.4 | 4.8 | 2.6 | 7.7 | 15 |
| 12 | 53 | 3 | 0.4 | 0.7 | 2 | 4 | 0.3 | 0.8 | 2 |
| 12 | 53 | 10 | 1.3 | 0.7 | 2 | 3.9 | 0.9 | 2.6 | 5 |
| 12 | 53 | 20 | 2.5 | 0.6 | 1.9 | 3.8 | 1.5 | 4.8 | 10 |
| 12 | 45 | 3 | 0.4 | 0.7 | 2 | 4 | 0.3 | 0.8 | 2 |
| 12 | 45 | 12.5 | 1.8 | 0.7 | 2.2 | 4.3 | 1.3 | 4 | 8 |
| 12 | 45 | 20 | 2.9 | 0.7 | 2.2 | 4.4 | 2 | 6.4 | 13 |
| 12 | 40 | 3 | 0.5 | 0.8 | 2.5 | 5 | 0.4 | 1.3 | 3 |
| 12 | 40 | 10 | 1.6 | 0.8 | 2.4 | 4.8 | 1.28 | 3.8 | 8 |
| 12 | 40 | 20 | 3.2 | 0.8 | 2.4 | 4.8 | 2.6 | 7.7 | 15 |
| 15 | 53 | 3 | 0.5 | 0.8 | 2.5 | 5 | 0.4 | 1.3 | 3 |
| 15 | 53 | 12.5 | 2 | 0.8 | 2.4 | 4.8 | 1.6 | 4.8 | 10 |
| 15 | 53 | 20 | 3.1 | 0.8 | 2.3 | 4.7 | 2.5 | 7.1 | 15 |
| 15 | 45 | 3 | 0.6 | 1 | 3 | 6 | 0.6 | 1.8 | 4 |
| 15 | 45 | 12.5 | 2.3 | 0.9 | 2.8 | 5.5 | 2.1 | 6.4 | 13 |
| 15 | 45 | 20 | 3.7 | 0.9 | 2.8 | 5.6 | 3.3 | 10.4 | 21 |
| 15 | 40 | 3 | 0.6 | 1 | 3 | 6 | 0.6 | 1.8 | 4 |
| 15 | 40 | 12.5 | 2.5 | 1 | 3 | 6 | 2.5 | 7.5 | 15 |
| 15 | 40 | 20 | 4 | 1 | 3 | 6 | 4 | 12 | 24 |
| 20 | 53 | 3 | 0.6 | 1 | 3 | 6 | 0.6 | 1.8 | 4 |
| 20 | 53 | 12.5 | 2.6 | 1 | 3.1 | 6.2 | 2.6 | 8.1 | 16 |
| 20 | 53 | 20 | 4.2 | 1.1 | 3.2 | 6.3 | 4.6 | 13.4 | 26 |
| 20 | 40 | 3 | 0.8 | 1.3 | 4 | 8 | 1 | 3.2 | 6 |
| 20 | 40 | 12.5 | 3.3 | 1.3 | 4 | 7.9 | 4.3 | 13.2 | 26 |
| 20 | 40 | 20 | 5.3 | 1.3 | 4 | 8 | 6.9 | 21.2 | 42 |

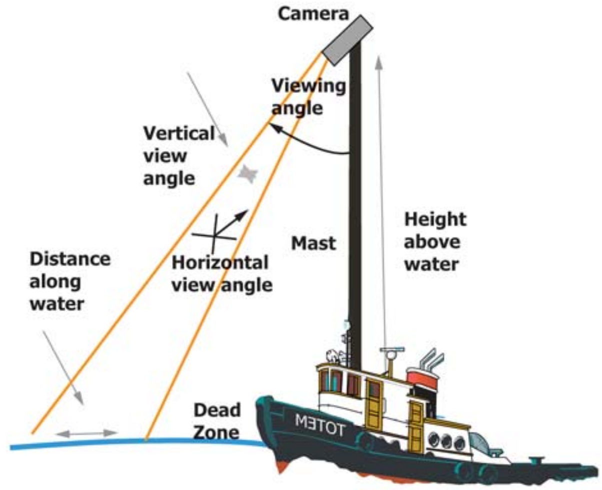


FIG. 1 Schematic of Camera View Geometry

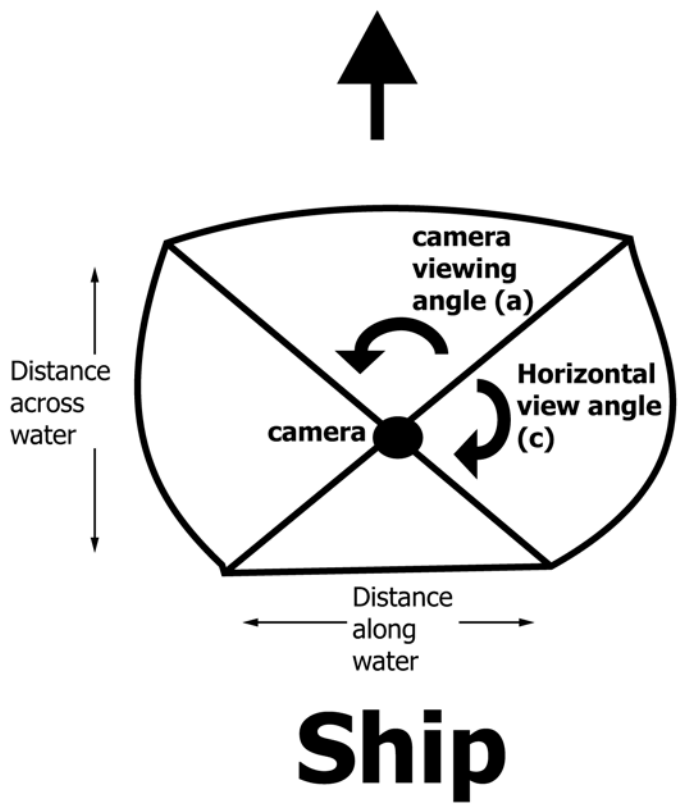


FIG. 2 Plan View of Camera View Geometry, Camera Looking Down