ISB OPERATIONS

IN-SITU BURNING

Things You Should Know

The decision to burn should be made early in an incident.

The main operational factors that influence ISB effectiveness are the spill characteristics and the readiness to respond. Slick thickness is the primary characteristic that determines if an oil spill can burn.

ISB response readiness includes trained and experienced responders with appropriate equipment for site conditions, ignition, personnel safety, fire control, and monitoring.

Burn plans should contain site-specific information on spill conditions, weather forecasts, regulatory and public safety notifications, ignition plan, fire control steps, personnel and equipment, and smoke plume behavior forecasts.

There are two main equipment requirements for ISB: 1) containment mechanisms to collect and maintain the oil at the thickness required for sufficient vapors for burning, and 2) igniting devices to heat oil to its ignition temperature.

Overview

In-situ burning (ISB) is a response technique that removes spilled oil from a land, snow, ice, or water surface by combustion of hydrocarbon vapors that yields predominantly carbon dioxide and water. ASTM International (2014) defines controlled in-situ burning as "burning when the combustion can be started and stopped by human intervention." The combustion by-products (particulates, gases, water, etc.) are released to the atmosphere, with the possibility of some unburned oil or incompletely burned oil residue remaining at the conclusion of a burn.

One of the greatest benefits from ISB is that a burn can rapidly reduce the volume of spilled oil and minimize or eliminate the need to collect, store, transport, and dispose of recovered oil and oily wastes. Decision-makers from federal, state and local agencies or other stakeholders must consider the benefits and risks of conducting a burn versus using other response options, since all options have potential environmental and human health risks. ISB also has the potential to significantly reduce the duration of cleanup operations. In certain instances, ISB might provide the only means of quickly and safely eliminating large amounts of oil.

ISB is used for the rapid removal of oil slicks on land or on water surfaces, which minimizes the spread and impacts of the oil to the surrounding environment.

Slick thickness is the primary characteristic that determines if an oil spill can burn. There is generally a short window of opportunity when a slick is capable of sustaining a burn, depending on often rapidly changing oil and site conditions. There are two main equipment requirements for ISB: 1) containment mechanisms to collect and maintain the oil at the thickness required for sufficient vapors for burning, and 2) igniting devices to heat oil to its ignition temperature. Safety regulations and air quality monitoring requirements are in place for ISB to ensure the on-going safety of its use.

This fact sheet summarizes in more detail ISB operations and oil spill response readiness.

Fact Sheet Series

Introduction

ISB is used for the rapid removal of oil slicks on land or on water surfaces, which minimizes the spread and impacts of the oil to the surrounding environment. When other removal methods are deemed to be inadequate for the response or have limited effectiveness, ISB provides another method to protect vulnerable land, shoreline and water resources. These circumstances include when access to a spill is difficult for responders and equipment to arrive on scene, or when the habitat is sensitive and other response options could cause more harm than good.

The decision to burn should be made early in an incident, taking into account its feasibility and appropriateness and with proper approval and guidance to make best use of windows of opportunity. Field Guides are available for both inland and on-water responses. These guides contain a set of operational checklists, tools, and references to assist in the conduct of in-situ burning of spilled oil. The two API technical reports are titled, Field Operations Guide for In-Situ Burning of Inland Oil Spills API Technical Report 1251, JULY 2015, and Field Operations Guide for In-Situ Burning of On-Water Oil Spills API Technical Report 1252, JULY 2015.

Factors Which Influence Burn Operations

The main operational factors that influence ISB effectiveness in an oil spill are the spill characteristics and the readiness to respond.

Spill Characteristics

Slick thickness is the primary characteristic that determines if an oil spill can burn. Slick thickness has two roles in establishing and maintaining an oil burn. It serves as a source of hydrocarbon vapors and sustains a burn by retaining heat through vaporization.If a slick is thick enough, it insulates the burn and reduces the heat loss to underlying media (i.e., water, soil, ice/snow). It also keeps the slick surface at a high enough temperature to continue to vaporize. As a slick thins during combustion, its insulating capacity declines and more heat is lost to the underlying substrate. Eventually, the oil temperature will drop, the concentration of vapors will become insufficient to sustain a burn, and it will extinguish. As long as heat transfer to surrounding media is minimized by maintaining sufficient slick thickness, an oil slick will be capable of sustaining a burn.

Additional factors that influence operational burns include wind speeds and habitat conditions. Lower wind speeds keep vapor concentrations ignitable by allowing the smoke plume to rise, which then draws more air into the fire from the sides.

Habitat conditions (e.g., dry desert land, wet peat bogs) can influence the movement of the oil and its ability to maintain an ignitable thickness.

Oil Spill Response readiness

During ISB, response readiness includes trained and experienced responders with appropriate equipment for site conditions, ignition, personnel safety, fire control, and monitoring. The development and use of clearly defined logistics, coordination, and communication plans are required for safe and effective operations.

There is generally a short window of opportunity when a slick is capable of sustaining a burn, depending on often rapidly changing oil and site conditions. For quicker, informed decisions, the multi-state Regional Response Teams (RRTs), state and/or local governments, and regulatory agencies can pre-approve burn zones in advance within their jurisdiction. These organizations jointly develop planning guidance for the use of ISB for the federal and state decision makers on the requirements for ISB use within the region (API, 2015). For more information on this topic, refer to **ISB Fact Sheet 5 – ISB Approval in the U.S.**

Influence of Habitats on Burn Site Conditions

Another factor that influences ISB effectiveness is the habitat of the spill location. The suitability of ISB can vary by habitat based on climate or weather conditions. Operational planning considers vegetation types, season, soil type, water level or sea state, and oil type. Habitats that are difficult to access or are sensitive to damage from foot or vehicular traffic are likely locations where ISB could be of most benefit.

Wetlands/Marshes

In wetlands and marshes, low water levels limit the use of fire booms to contain the oil and a burn. Vegetation in these habitats usually recovers the slowest when ISB has been conducted during summers. Higher vegetation recovery rates tend to occur for areas subject to ISB during winter or early spring dormancy when the above ground vegetation has died back naturally.

Land

Operational planning for ISB on land should take into consideration the vegetation present, seasons, soil type, water level (if present), oil type and proximity to infrastructure and population centers. Open forest or grassland communities can contain species that are fire tolerant. Burns in winter tend to result in less plant damage, while burns in spring and summer could result in higher mortality to larger plants and hardwoods because of their increased susceptibility to stress.

Marine and Inland Waters

Oil on marine and inland waters often need to be collected and contained to maintain a thickness that allows for ignition and sustainment of a burn. To accomplish this, fire-resistant containment booms have been developed. **Figure 1** shows how boats are used to pull these booms while conducting a burn.

Snow and Ice

Snow and ice function as natural barriers to contain and thicken oil or to absorb oil and slow spreading. Burning oil-contaminated snow requires an initial pool of free oil to be ignited. As snow melts around a burn, remaining oil is released from the snow onto a layer of water where its vapors can be ignited (API, 2016). Oil spilled on ice tends to spread at a much slower rate than on water, and covers a smaller final area (Buist et al., 2013). Oil spilled on water in broken sea ice can still be contained by that ice and could be ignitable without additional containment.

Burn Planning

In advance of ISB, the preparation of a burn plan is highly recommended. Burn plans are strategic and tactical documents which direct the execution of a burn (API, 2015a and 2015b). Burn plans should contain site-specific information on spill conditions, weather forecasts, regulatory and public safety notifications, ignition plan, fire control steps, personnel and equipment, and smoke plume behavior forecasts. Equipment and personnel for ignition, fire control, and monitoring should be listed with their staging and sequencing specified. Tasks for any post-burn treatment and recovery monitoring should be described.

Planners can learn from the burn history of a location (including wildfires or man-made prescribed burns). Historical data would include species that live within the area, prescribed burn success in the area, and the long term effects from previous wildfires.

FIGURE 1. ISB conducted on the water by containment within a fire boom. (Mabile 2012)

Incident Management

The Incident Command System (ICS) is a response method universally adopted by state and federal agencies that describes how to rapidly organize a coordinated response to an incident. An ICS is expanded to a Unified Command when multiple organizations and jurisdictions are involved. An Incident Management Team (IMT) – which can be comprised of individuals from the government and private sectors working together under the ICS framework – responds to and manages oil spill emergencies. As part of the Operations Section of an IMT, an ISB Operations Group is established to conduct and manage burn operations. Personnel functions within this group include ignition, fire suppression, air quality monitoring, and residue recovery positions. The size and complexity of an ISB Operational Group aligns with the size and complexity of the intended burn

Additional local information can be provided by government land managers who often have experience using prescribed fire as a land-management tool. This expertise from prescribed fire practitioners can be useful during an inland burn to evaluate a proposed burn plan and to provide tactical assistance in burn execution (API, 2015a and 2015b).

Equipment Requirements for ISB

There are two main equipment requirements for ISB: 1) containment mechanisms to collect and maintain the oil at the thickness required for sufficient vapors for burning, and 2) igniting devices to heat oil to its ignition temperature.

In addition, vessel and aerial support provides the opportunity to monitor the burn as well as collect air and water samples.

Containment

It is important to quickly contain spilled oil, whether on land or on water, to limit its spreading and maintain its necessary thickness for ignition and sustained burning.

On water, different types of fire-resistant booms (water-cooled, stainless steel, thermally resistant, and ceramic) are used to collect oil for ISB. Original designs resisted heat by using ceramic fabric while others were constructed from stainless steel. Some newer designs use temperature-resistant metal mesh fabrics, and others use cooling water supplied by internal hoses from a towing vessel to soak fire-resistant material covering the boom. It is important to verify your boom capabilities prior to an ISB given the varying designs and response capabilities. Booms also help control the lateral movement of oil on water and provide an operational safety factor as they can be released to allow the oil to spread, thin and extinguish the flames.

An effective boom towing vessel is one with the ability to maintain a sustained low towing speed under load (USCG, 2003). Desirable vessel characteristics include: controllable pitch propeller/trolling gear for very low speed operations, bow thrusters for low-speed maneuvering, and accurate speed indicator relative to the water current.

On land, natural and man-made containment allows the spilled oil to thicken; these include dikes, snow berms, or ditches. Other physical barriers include snow, ice, debris and shorelines (API, 2015a). Oil also accumulates in natural land depressions and low-laying areas.

Igniters

Combustion of hydrocarbon vapors occurs when an external igniter heats oil, generating enough vapors to ignite and sustain a burn. Various ignition devices can be used for ISB depending on the type of oil and the newness of the spill.

A handheld igniter can be used at ground level or from a vessel or helicopter on fresh oil with a sufficient quantity of hydrocarbon vapors. Most handheld igniters have delay fuses that allow a safe time for the igniter to be thrown. The igniter fuels consist of solid propellants, gelled kerosene cubes, and reactive chemical compounds (USCG, 2003).

A Heli-torch is an igniter that can be used on oil that is more difficult to ignite. This igniter emits a stream of gelled fuel that is ignited as it is released. Additional igniters include propane torches, road flares, and oil soaked rags. Another option is a plastic spherical igniter that can be launched from ground level or from the air. These spheres are injected with chemicals that react thermally to cause the spheres to burn. After launching, the spheres heat the oil and generate vapors for ignition.

Ignition promoters are additives that can be used to ignite highly weathered or emulsified oil and also help to spread the flame. These additives are light, easily ignitable oils that are added to a spilled oil slick start a small burn and then generate enough heat to ignite the larger oil slick.

Aerial Support

Aircraft, similar to the one in Figure 2 can provide a viewing platform to monitor burn progress, check fire control, and collect plume samples for air monitoring at altitude. For burns on water, spotters in aircraft can help direct boom-towing boats towards thicker oil, take visual measurements to calculate the amount of oil burned, and support vessel safety.

FIGURE 2. Aerial observation of a peat bog burn. (EPA 2002)

ISB Operational Roles

There are nine possible response roles in execution of an ISB: 1) Burn Boss, 2) Safety Officer, 3) Fire Control or Firefighter, 4) Ignition Specialist, 5) Air Monitoring, 6) Vessel Captain and Deck Hands for small boat operations for on-water burns, 7) Aerial Survey or surveillance, 8) Skilled Support, and 9) trained Observers. Descriptions of key competencies and training recommendations have been developed for each role (API 2016).

Operational Safety Considerations

ISB operational and safety plans address anticipated hazards associated with preparation, ignition and control of burns. The plans address personnel and logistical support for ISB, including operations involving igniters, boats, booms, skimmers, and support barges.

Fire Hazards

For inland burns, deploying on-scene firefighting personnel should be considered to prevent fires from spreading beyond the oiled area. For burns on water, responders and vessels must remain a safe distance from the burn. Response personnel need to continuously observe a burn to ensure it takes place in its designated area. If it deviates in terms of intensity or location, a burn might need to be extinguished.

A natural or man-made firebreak assists with containing the fire to a pre-determined perimeter around the proposed burn area. Firebreaks can be constructed by creating dikes or by tilling the ground to bare soil (API, 2015a). In lieu of or in addition to a fire break, fire retardant and/or wetting the perimeter can prevent spreading. Similar to wetlands and marsh burns, wetting a perimeter with water as a fire break can also help insulate the soil and plant roots from heat.

Personnel Safety

Response personnel may be in danger from the fire or flames, exposure to high concentrations of combustion by-products, or other health and safety issues, such as working in extreme heat or cold conditions (API, 2004). For exposure combustion by-products, response crews need to be concerned about the two major routes of exposure (inhalation and skin absorption) and use appropriate personal protective equipment (PPE), including respirators, if needed, and specialized training to reduce exposure risks.

Safety regulations and air quality monitoring requirements are in place for ISB to ensure the on-going safety of its use. In the U.S., the Special Monitoring of Applied Response Technologies (SMART) describes protocols for an offshore burn. These protocols include monitoring and evaluating response effectiveness as well as establishing a rapid collection and reporting of real-time data to the decision-makers. Particulate monitors could be placed downwind if a community had the potential for exposure to a smoke plume. Precise monitoring locations are flexible and are determined on a case-by-case basis.

For burn safety, ISB responders need to wear appropriate PPE, including fire resistant clothing. Flammable hydrocarbon levels need to be monitored before ignition to prevent flashback during ignition. To prevent unwanted ignition or secondary fires, fire control and ignition control personnel require additional safety precautions, such as specialized equipment and training.

In addition, vessels are recommended to remain upwind and as far as possible from a fire. Ongoing efforts should be made to keep responders out of a smoke plume and to move them as quickly as possible when conditions changed. Additionally, particulates can impede visibility and could pose a safety hazard to operators of ships, aircraft, and motor vehicles in the immediate vicinity of a fire (API 2016).

Aerial and Vessel Safety

Some ISB operations could use several vessels for boom deployment, fire oversight, ignition, rescue, and monitoring as well as aircraft for ignition and monitoring. This close proximity of logistical support aircraft and vessels requires established safety plans and experienced, trained personnel. Ignition of the oil slick needs careful consideration, as involvement of aircraft for aerial ignition is coordinated by experienced, trained personnel. Weather and water conditions are monitored, and safety distances are set and adhered to throughout the spill and response phases.

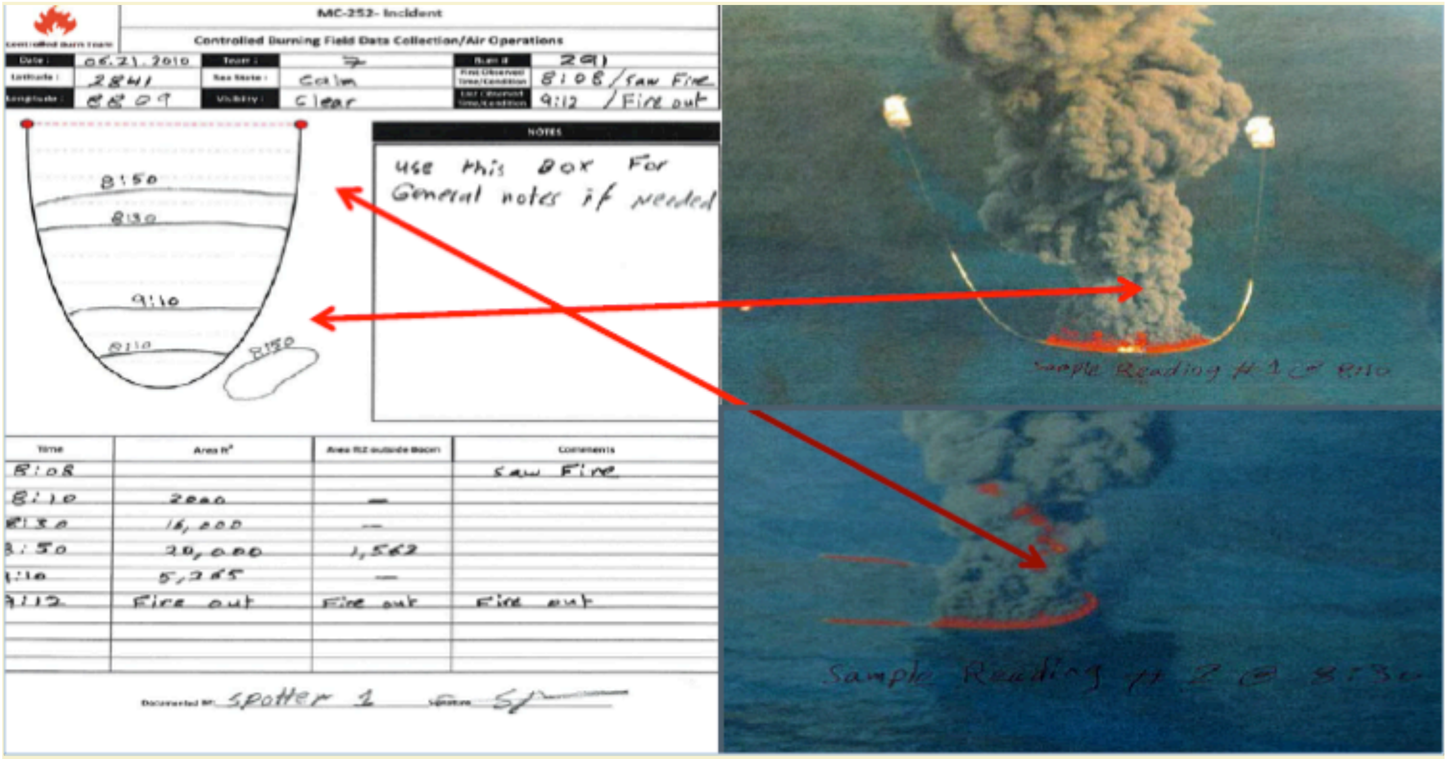
Burn Effectiveness

Operational effectiveness is primarily judged by how quickly oil is removed from a surface. Depending on oil spill conditions, removal rates have been empirically measured as high as 90+ percent of encountered oil (Allen, 1991). When all conditions are right and the oil can be contained, a 90 percent or greater removal rate on water can be expected. Under ideal conditions, ISB can achieve removal rates of 98 percent or better (Allen, 1991)

Estimating Volumes of Oil Removed or Burned

Oil removal rates are a function of its size, thickness, oil type, degree of emulsification and environment conditions (wind, sea state, etc.). The volume of oil removed by burning is estimated by multiplying the burn area by the duration of the burn, using an average burn rate of 0.05 – 0.07 gal/min/ft2 (Mabile 2012). **Figure 3** shows how an estimate is made during an on-water burn using field data collection reports. For spills on water, burning will cease at slick thicknesses of 1-2 mm as heat to release more vapors for combustion is increasingly transferred to the underlying water and the slick cools.

FIGURE 3. Field calculations example from the Deepwater Horizon incident. (Mabile 2012).



Collecting Burn Residue and Unburned Oil

ISB does not remove all oil by combustion and results in residue and unburned oil after the fire is extinguished. Residues vary depending on the type of oil – residues from burns of medium oils can form mats or sticky accumulations, while burns of lighter oils tend to form liquid residues. The residue from on-water burns of heavy oils can result in heavy residues which might sink.

If practical, the residue should be evaluated and collected after the burn is extinguished. Liquid residues and unburned oil from on-water burns can be recovered using mechanical skimmers or sorbents. If the unburned oil is able to be collected into an ignitable thickness, then this unburned oil could be ignited (API, 2015a and 2015b).

Recovery of solid residues on land can be done manually or with mechanical equipment and recovery of residues from inland lakes and marshes can be done using nets or manual tools. Careful consideration should be given to the collection of residue, the benefits from collection should be weighed against the potential damage from responders and equipment used for residue collection (API, 2015a and 2015b).

Figure Sources

Figure 1 – Mabile, N. (2012). Considerations for the application of controlled in-situ burning. SPE/APPEA International Conference on Health, Safety, and Environment in Oil and Gas Exploration and Production, 2(2), 72-84. doi:10.2118/157602-PA

Figure 2 – EPA. 2002. A Crude Oil In-Situ Burn in a Peat Bog – Photo. Retrieved from: https://archive.epa.gov/emergencies/content/fss/web/pdf/leppala_04.pdf

Figure 3 – Mabile, N. (2012). Considerations for the application of controlled in-situ burning. SPE/APPEA International Conference on Health, Safety, and Environment in Oil and Gas Exploration and Production, 2(2), 72-84. doi:10.2118/157602-PA

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