



In Situ Burning – An Overview

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Outline

- How In-Situ Burning Works
- Why Burn?
- IOGP-IPIECA Work Products (IPIECA - *International Petroleum Industry Environmental Conservation Association*)
- API ISB Work Products
- *Soil Heating*
- *Ignition Enhancement*
- *Equipment Selection*
- *Good Practice Guidance*
- *Operational Guidance*
- *Decision Making*
- *Safety and industrial Hygiene*
- *Emissions Comparison*
- *Selection and Training of ISB personnel*
- *ISB Fact Sheets*



How In-Situ Burning Works

DEFINITION: *ISB removes spilled oil from a land, snow, ice, or water surface by combustion of hydrocarbon vapors and yields predominantly CO₂ and water to the atmosphere.*

- 💧 Burning occurs in the vapor phase as hydrocarbons evaporate
 - 💧 The middle of a fire may be 1000°C or higher
 - 💧 The surface of oil must remain above 400°C to sustain a burn
- 💧 Depending on slick thickness, high removal rates can be achieved
 - 💧 Typically, burns are short lived (minutes to hours)
- 💧 Natural gas blowouts burn completely, but oils do not
 - 💧 Incomplete combustion can lead to black smoke
 - 💧 Smoke is predominantly carbon particulates
- 💧 High-density residues can remain after a burn
 - 💧 Relatively inert, i.e., not bioavailable, and easy to collect on land
 - 💧 Can sink or submerge and be difficult to recover for spills on water



Why Burn?

Advantages

- Good for remote regions or those with difficult access
 - Less equipment and labor required
- Minimizes intrusive impacts from mechanical response on sensitive habitats
- Can be used on water, on ice, and on land
- High efficiency removal rates (up to 98-99%) of encountered oil
 - Areas can be re-burned, as needed
 - Much less waste for disposal



Constraints

- Limited window-of-opportunity on open water
 - Emulsified oils do not burn well (difficult when water content >30%)
- Minimum thickness required to ignite and sustain a burn
- Residue can be difficult to recover (can submerge / sink)
- Smoke plume is an aesthetic issue and particulates may be a health concern
- Fire booms for on-water burns have limited life, but during Macondo, boom could be used in number of burns lasting for hours
- Possible risk of fire spreading (safety)

IOGP-IPIECA Work Products

- 💧 **Guidelines for the selection of ISB equipment**
- 💧 Document on ISB residues and plumes (CEDRE & INERIS)
- 💧 **Good Practice Guide – Controlled ISB of spilled oil**

*Note: Work products in **bold** will be discussed in further detail*



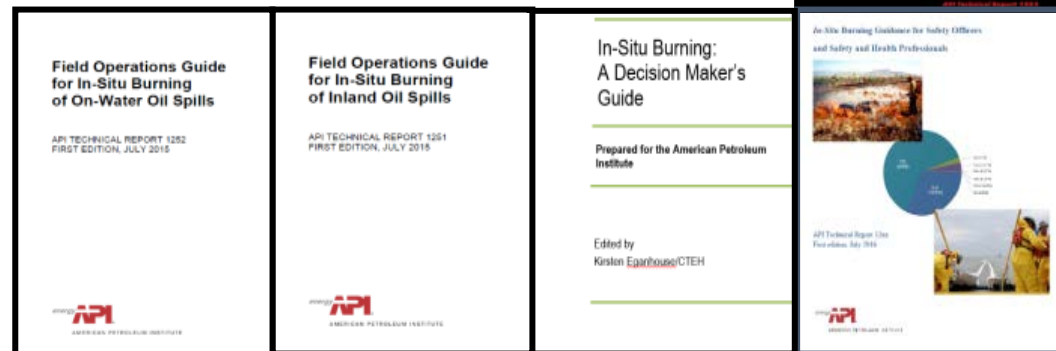
(IPIECA -International Petroleum Industry
Environmental Conservation Association)

(International Oil and Gas Producers)

API ISB Work Products

- 💧 **ISB: A Decision Maker's Guide**
- 💧 **Field Operations Guides for ISB of Inland and On-Water Spills**
- 💧 **Fact Sheet Series**
- 💧 **ISB Guidance for Safety Officers and Safety and Health Professionals**
- 💧 **ISB SH FAQs**
- 💧 **Selection and Training Guidelines for ISB Personnel**
- 💧 **Comparison of Emissions from Burning of Petroleum, Petroleum-Derived Fuels and Common Vegetative Fuels**
- 💧 **Soil Heating from ISB**
- 💧 **Ignition Enhancement**

*Note: Work products in **bold** will be discussed in further detail*

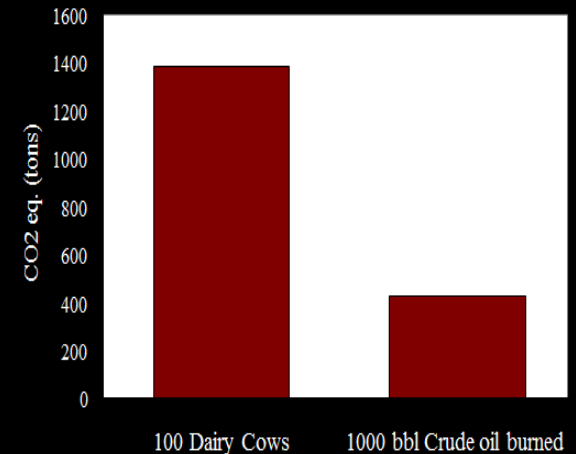


(American Petroleum Institute)

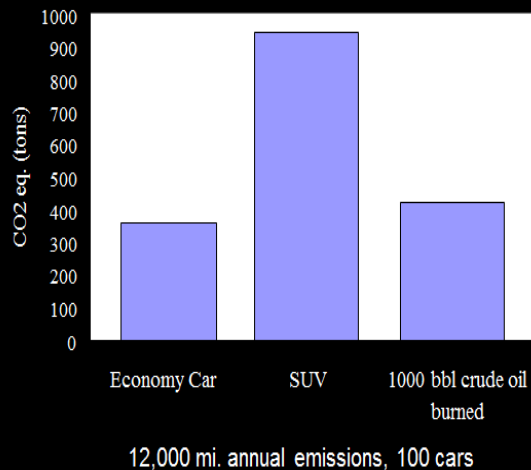
Past API Focus on ISB

- Considered emissions compared to:
 - Wild fires
 - Car emissions
 - Cow emissions
- CO₂ is the major GHG from ISB
- Aerosol and soot from ISB are not significant cooling contributors
- 1000 bbl ISB is equivalent to a 10-acre wildfire (25 tons/acre) in terms of GHG emissions

Annual Emissions In-situ Burning vs. Dairy Cows



In-situ Burning vs. Car Emissions



Oil Spill Response
Summary of In-Situ Burn Practitioners Workshop
December, 2008

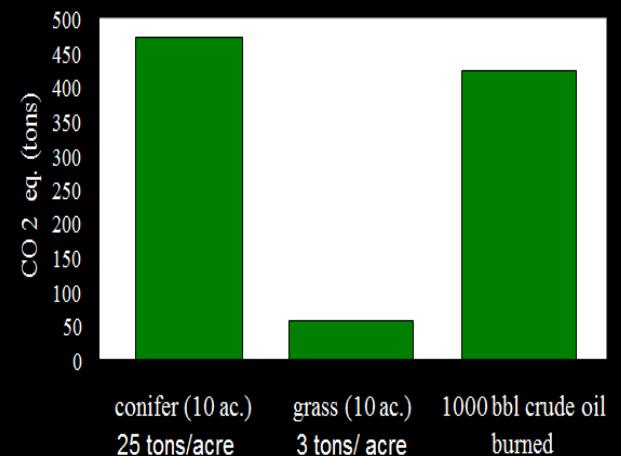
Freshwater Spills Symposium

St. Louis
April, 2009

Marc Hodges – Emergency Response Coordinator
American Petroleum Institute

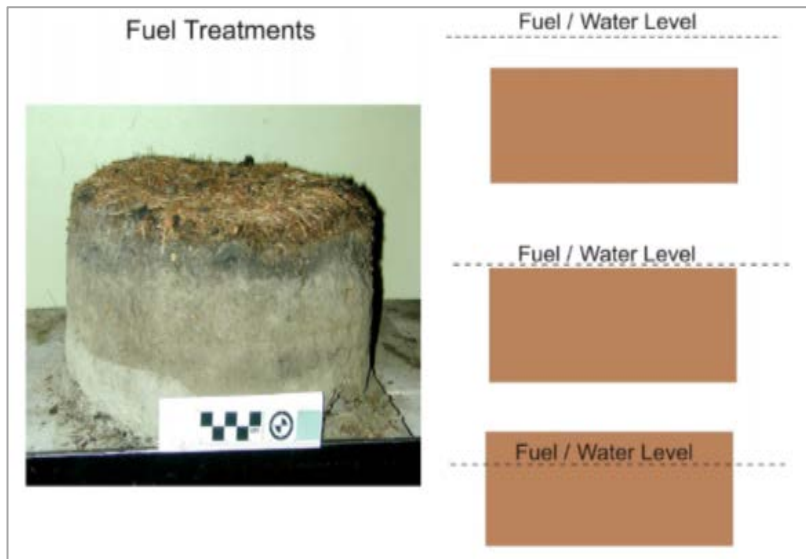
Toni Coolbaugh – Distinguished Scientific Associate
ExxonMobil Research & Engineering

In-situ Burning vs. Vegetation Fires



Soil Heating from In-situ Burning

- **Objective:** Conduct soil heating tests on possible effects to soils and plants from ISB
 - Core burns to measure soil heating with a variety of soils, moisture conditions (wet, dry, standing water), and petroleum products
 - Develop a fire behavior module from ISB based on 'USFS' First Order Fire Effects Model
- Potential for higher heat profile (BTU) with hydrocarbons versus forest fires
- Different temperature profiles at different soil depths



2 oil types with 3 soil moisture levels tested



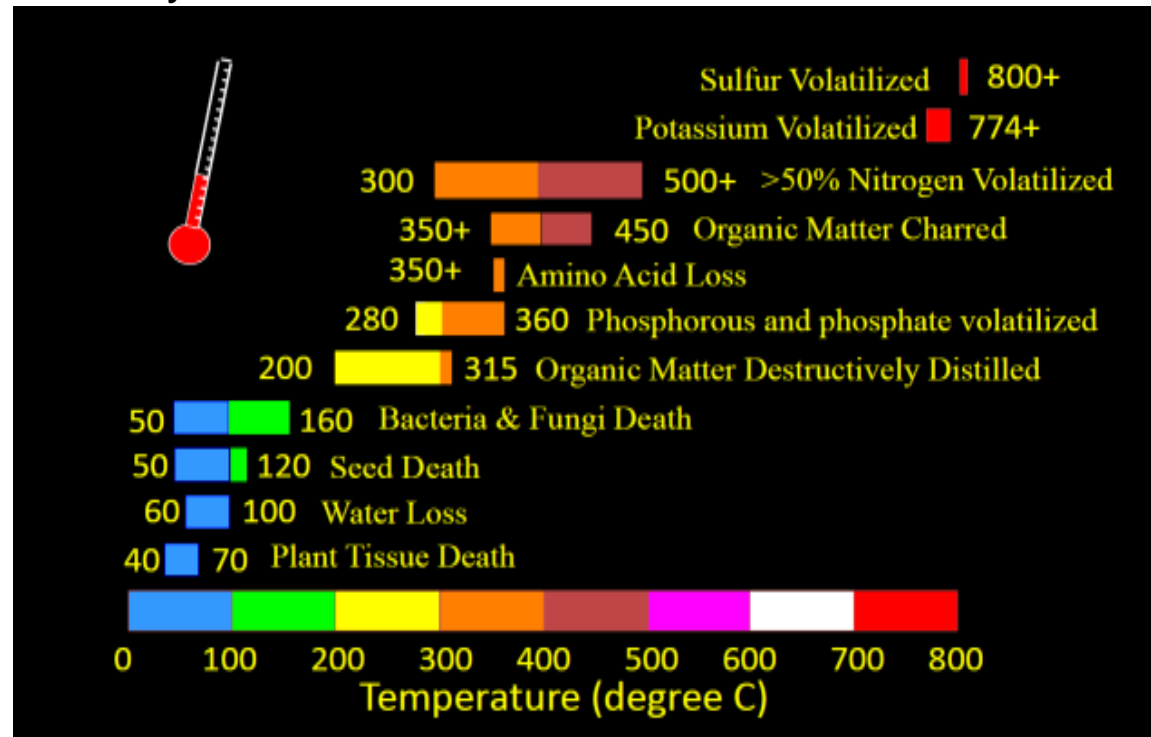
Figure 3. One of the Soil Core Test Burns.

<http://www.interspill.org/previous-events/2015/WhitePapers/Interspill2015ConferenceProceedings/24-MARCH-2015/Inland%20Spills/In-Situ-Burning-and-Soil-Heating-J-Myers-Chevron-A-Steen-ExxonMobil.pdf>

Soil Heating from In-situ Burning

Conclusions

- Aligned with wildfire fire behavior model for heat transfer
- Maximum soil temperatures were **below** threshold expected to negatively effect plants and soils – suggesting **soil sterilization does not occur**
- Saturated soils, with **water at soil surface could insulate against ISB heat**; standing water is unnecessary
- Developed ISB module to estimate heat effects for burn planning.
- Post-burn soil CO₂ respiration rates were slightly heightened



Known range of effects on plants and soils with increasing temperature

Ignition Enhancement

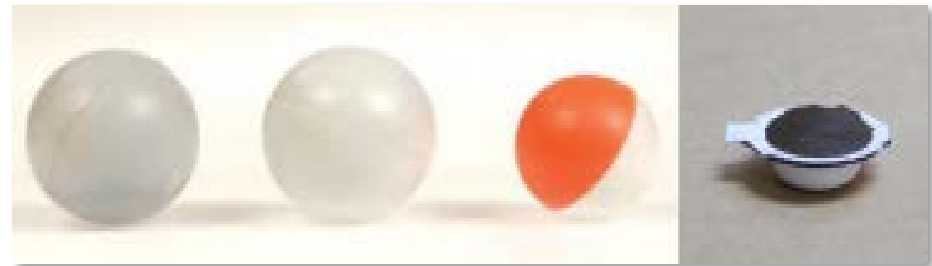
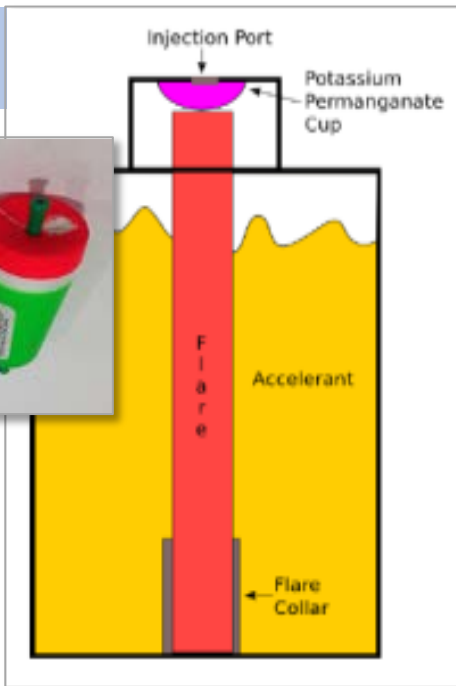
Objective: Evaluate ignition devices and aircraft to improve safety, burn reliability, targeting

- Scope:
 - Examine performance of existing ignition systems
 - Work with manufactures on testing and improvements for aerial ignition (fixed and rotary wing platforms); Potential to develop new or modified igniters

Proposed Igniters:



- Stays upright
- 'Dunkable'
- Waterproof
- Floats
- Access to oxygen



KMnO₄ capsules: Premo, Aerostat, SEI Dragon Egg, and Raindance R3

ISB Equipment Selection Guidelines

Objective: Compile and summarize equipment efficiency information for use by operators, responders and regulators.

- Focused on equipment for on-water burns

Factors		Actively water-cooled systems	Inflated fire boom	Solid fire boom
Storage space on deck	Limited space required (reels)		✓	
	Clear deck space required (flaked/zig-zagged)		✓	
Deployment time	Ongoing operations, deployment time less important		✓	
	Small short-term operation			✓✓
Deployment team	Training required			
	General oil spill response workers, or leveraged from locally available resources			

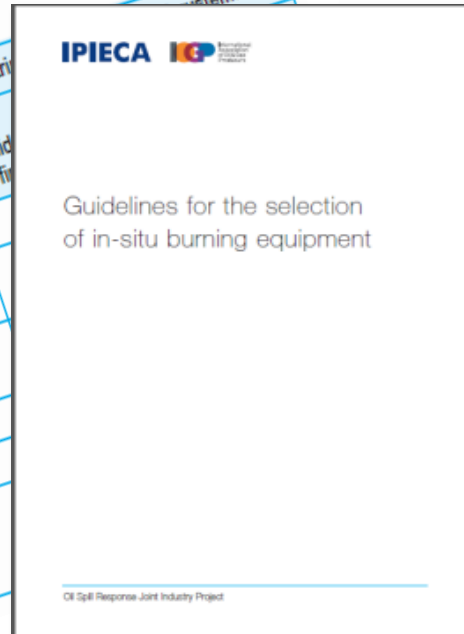


Table 4 Summary of ignition devices and their characteristics

[illegible]

ISB Good Practice Guide Content Synopsis

Science of burning

Ignitable vapors, combustion and oil removal rates

Decision-making

Use of NEBA, typical regulatory approvals before use, health and environmental issues, feasibility of use

Application

On-land and on-water spills, hazards (e.g. , smoke plumes), planning and execution

Equipment

Igniters, ignition platforms, booms, support vessels and aircraft

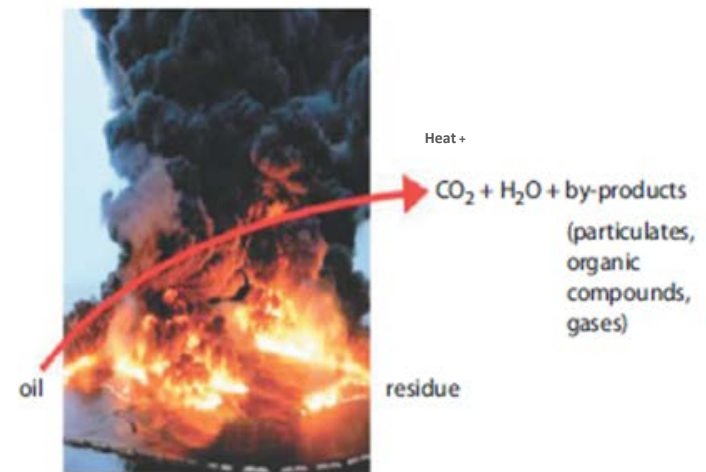
Monitoring

Heat, emissions, fire control, habitat recovery

Appendices

1. Oil removal and efficiency estimation
2. Boom deployment and towing configurations

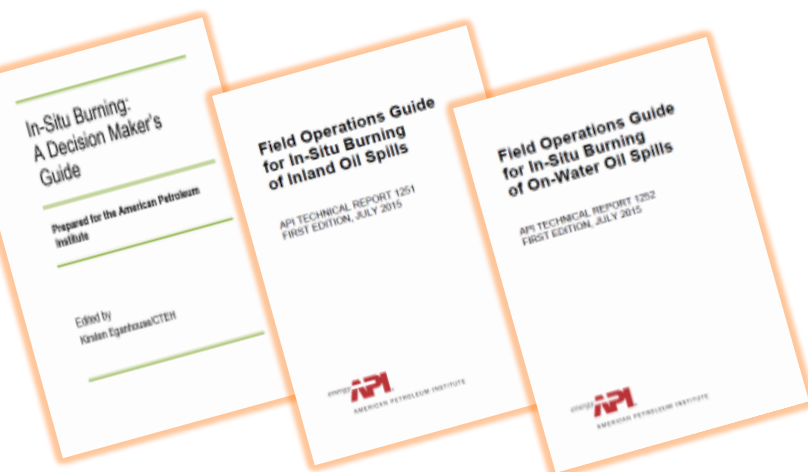
Appropriateness	Feasibility
<p>Is the location suitable for burning?</p> <ul style="list-style-type: none"> Distance from populated areas Burn distance from other combustibles Distance of smoke plume trajectory from residences 	<p>Is the oil burnable?</p> <ul style="list-style-type: none"> Oil can be ignited (<25–30% evaporated) Oil is thicker than 2–3 mm Emulsification: <20–25% water
<p>Is burning feasible, and can burning be carried out safely?</p>	<p>Weather forecast?</p> <ul style="list-style-type: none"> Winds <18 knots for ignition/ <20 knots for a sustained burn If booms are necessary, is wave height <1 m?
<p>Legislation and regulations</p> <ul style="list-style-type: none"> Can necessary permissions be obtained? Can necessary conditions be met? 	<p>Equipment availability?</p>



<http://oilspillresponseproject.org>

API Operational Guides and Decision Making

- **ISB Operational Guides: On-water and Inland**
 - Objective: provide operational guidance for burn execution
 - Concise, booklet format
 - Checklists provided and **Red Flag** conditions noted
 - Appendices on weather and smoke mgmt., ignition, fire control, removal estimates, air quality monitoring, and residue recovery
- Updated: **Decision-Making** publication
 - Objective: update 1995 API publication post-DWH
 - US local, state, and federal decision-making processes; US laws and regs.
 - Includes oil weathering, health and safety, wildlife and environment



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VII.4 Habitat Recovery Following ISB	

Safety and Industrial Hygiene Guidelines

- Types of ISB emissions
 - Smoke plumes often of greatest concern for responders and public, though actual health risks from ISB likely minimal
- ISB hazards: working environment
 - Latest exposure thresholds for key gases, VOCs, and particulates
 - ISB emissions exposure thresholds
 - For each hazard (chemical or physical), risks and control measures are ID'd
- ISB incident templates
 - Safety and Health plan
 - 'Job Safety Analysis' forms
- Safety Officer performance qualifications
 - Aligned with API ISB Selection & Training

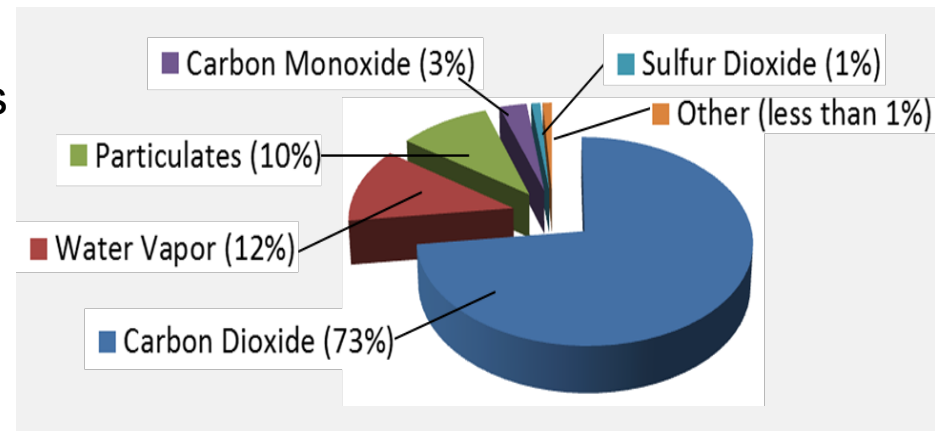


Figure 2. Typical Combustion by-products from burning crude oil. Source: modified from (Ferek, 1997)

Working-Environment Safety & Health Information

Table 9. Hazards and Control Measures for Smoke Plumes

Hazard	Risk/Effect	Controls
Black smoke ^a (Moderate to High Risk)	Loss of ability to see other responders or operations	A, B, C , D, E, F, G, H , I, J, K, L, M, N, O, Q
	Disorientation	
	Concern of public and responders as to their health and health of environment	
	Create shorting or grounding in high voltage power lines	
Airborne smoke particulates (soot) ^b (Moderate to High Risk)	Fine PM is small enough to access the gas exchange regions of the lung when inhaled	A, B, C , D, E, F, G, H , I, J, K, L, M, N, O
	At moderate to high concentrations it is an eye, nose and respiratory irritant	
	High concentrations can cause persistent cough, phlegm, wheezing, and difficulty breathing	
	May be transported considerable distances from the combustion source, resulting in potential inhalation exposures for a wider area of the public	
	EPA NAAQS PM levels may be exceeded	
Additional combustion by-products ^c (Moderate Risk)	Levels of CO could be high in plume. Past monitoring has not found CO to be an issue if there is no entry into the plume	A, B, C , D, E, F, G, H , I, J, K, L, M, O
	Overexposure to CO may result in headache, nausea, dizziness, confusion and at high levels, asphyxia and death	

Control Measures Key

(Examples):

C – Train personnel to never position themselves or their teams immediately downwind of smoke plume.

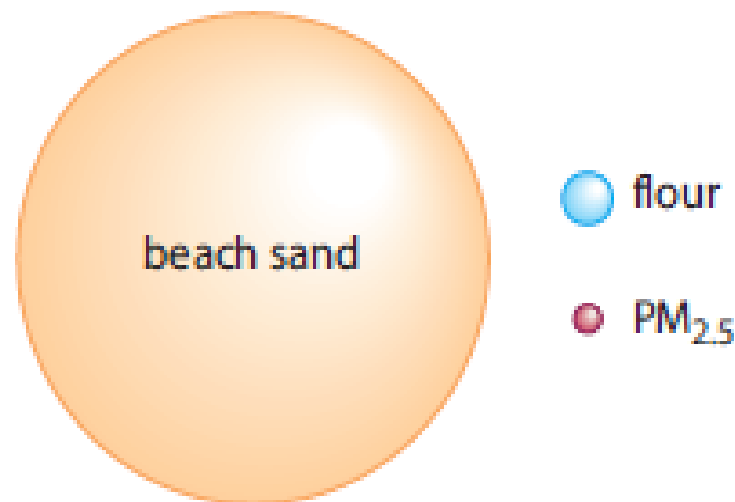
H – Ensure communications plan is in place and meets needs of responders and support teams.

Emissions Comparison Findings

- Primary ISB emissions of health concern are coarse (PM_{10}) and fine ($PM_{2.5}$) particulate matter and PAHs.
 - Total emissions reflect emissions rate and amount of fuel (hydrocarbon or vegetative) consumed
- ISBs are typically short-duration events lasting minutes to hours
- ISB airborne emissions factors are similar to natural or intentional burning of plant matter
 - ISB of crude produces $PM_{2.5}$ and PAHs potentially similar to wildfires and controlled agricultural burning

Figure 1 *Relative particle sizes*

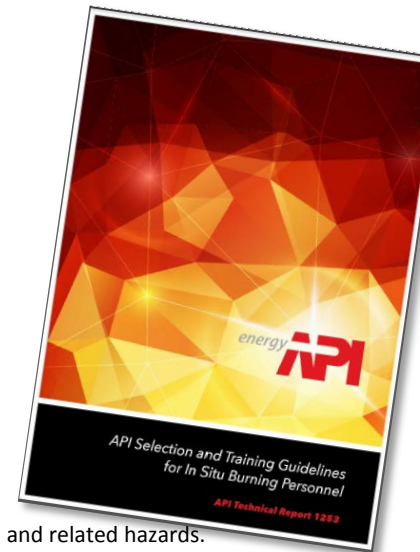
(based on data courtesy of the National Wildfire Coordination Group)



Selection and Training of ISB Personnel

Objective: Guidelines for ISB responders

- Covers ISB operations for terrestrial, open water, and on-ice burns
 - IDs competencies, performance requirements, knowledge, and skills
 - Based on NFPA¹ approach for competence with hazardous materials (#472)
 - Aligned with OSHA standard for responders (#3172)
 - 10 ISB jobs with specific performance expectations and duties



¹ Founded in 1896, NFPA is a global, nonprofit organization devoted to eliminating death, injury, property and economic loss due to fire, electrical and related hazards. NFPA delivers information and knowledge through >300 consensus codes and standards, research, training, education, outreach and advocacy.

Selection and Training of ISB Personnel, con't

- Competency categories: analyze, plan, execute, evaluate, terminate, and training/physical fitness
- Selection and training principles
 - Flexible, so training can be adjusted to fit circumstances and needs
 - Acceptance of job experience in lieu of training

0	ADMINISTRATION	
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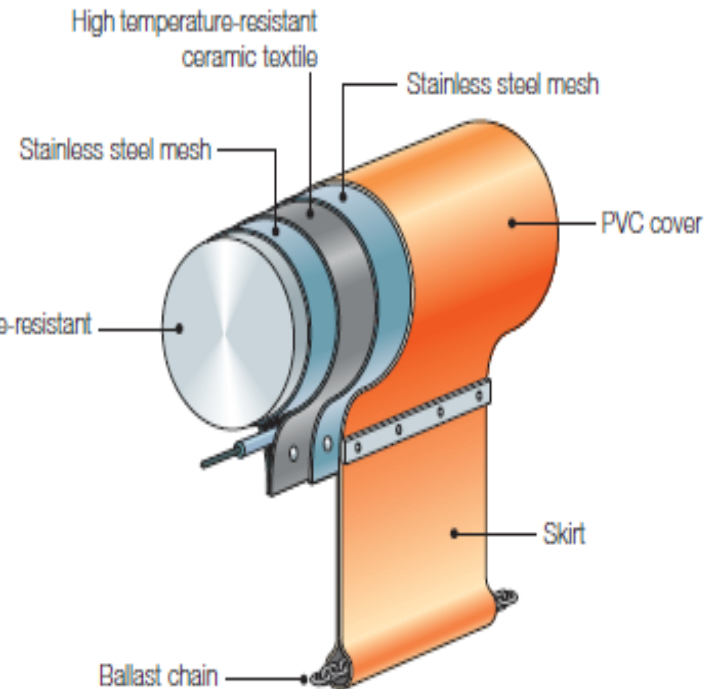
Position: Competency Matrix

Position → ----- Competency↓	Burn Boss	Safety Officer	Vessel Captain	Fire Fighter	Ignition Specialist	Deck Hand Small Boat Operations	Air Monitoring	Skilled Support	Aerial Survey	Observer
Oil Hazards	X	X	X	X	X	X	X	X	X	X
Sensitive Resources	X		X	X	X			X*	X	X*
Risk to Environment	X							X*		X*
Task Force Tactics	X	X	X	X	X	X	X	X*	X	X
Vessel Navigation			X							
Vessel Handling			X							
Small Boat Safety	X	X	X		X	X	X	X*		
Spill Control Agent Usage	X	X			X					
PPE	X	X	X	X	X	X	X	X		X
On-Water Ignition	X	X	X		X					
Ignition on Land / Ice	X	X			X					
Aerial Ignition	X	X			X					
Ops Briefing	X	X	X	X	X	X	X	X	X	X
Boom Deployment	X	X	X		X	X				
Boom Towing		X	X			X				
Deck Hand Small Boat	X		X		X*	X	X*	X*		
Fire Fighting	X	X	X	X	X	X	X	X*		
First Aid	X*	X*	X*	X*	X*	X*	X*	X*		
Air Monitoring	X	X					X			
Aerial Survey	X								X	
Worker Exposure	X	X	X	X	X	X	X	X	X	X
Response critique	X	X	X	X	X	X	X	X	X	
Impact to Environment	X						X	X*		
OSHA HAZWOPER	24	24	24-24	24	24	24-24	24	24	Brief	Brief

ISB Fact Sheet Series

- Multi-page, high-level documents for public consumption
 - Introduction to ISB
 - Fate of burned oil
 - ISB human health and environmental effects
 - Assessing ISB benefit and risks
 - ISB approval in the U.S.
 - ISB operations

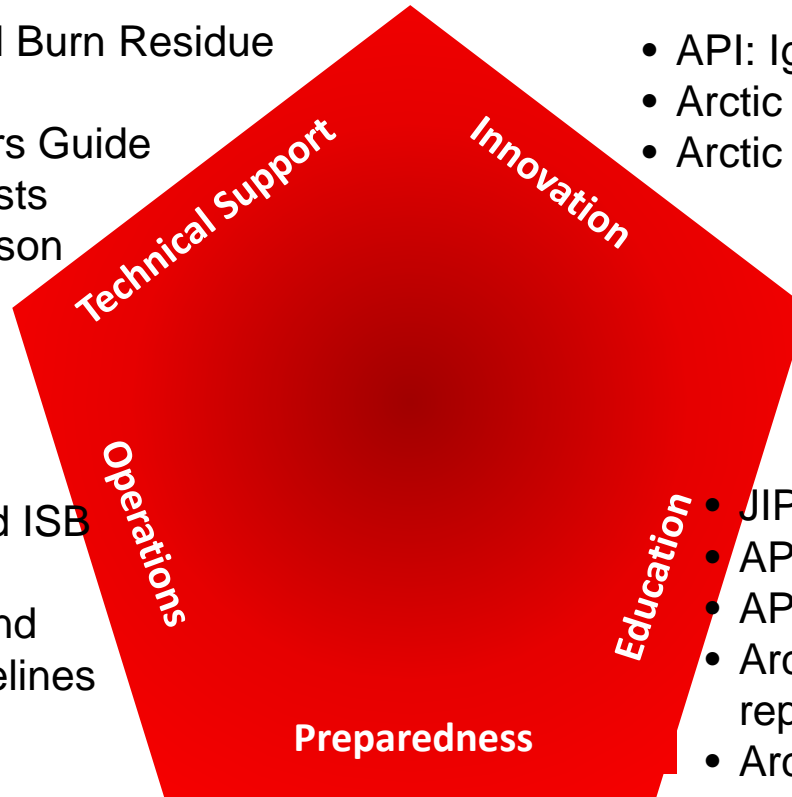
Figure 3 Solid flotation fire boom (intrinsically fire resistant boom)



Synopsis of ISB Topics

- JIP 5: Smoke Plume and Burn Residue Evaluation
- API: ISB Decision-Makers Guide
- API: ISB Soil Heating Tests
- API: Emissions Comparison

- API: Ignition Enhancement
- Arctic JIP: Herder Field Tests
- Arctic JIP: Aerial Ignition Systems



- API: On-Water and Inland ISB Operations Guides
- API: ISB Safety Officer and Industrial Hygienist Guidelines

- JIP 5: ISB Good Practice Guide
- API: ISB Fact Sheets
- API: ISB Safety and Health FAQs
- Arctic JIP: State of Knowledge reports
- Arctic JIP: Herder educational materials

- JIP 5: Equipment Selection
- API: ISB Responder Selection and Training Guidelines



**Any burning
questions?**

