Marine Induced Polarization

An Electrical In-Water Hydrocarbon Detection Technology

Presentation
March 29, 2018

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Alaska Oil Spill Technology Symposium
March 28 – 30, 2018
The Hilton Hotel
Anchorage, Alaska
March 29, 2017 – “If you can’t see spilled oil, how do you find it and clean it up?”

Office of Response and Restoration

High Water and Sunken Oil on the Great Mississippi

March 29, 2017 - If you can’t see spilled oil, how do you find it and clean it up?

That’s the situation emergency responders faced in two oil spills on the Mississippi River that challenged their understanding of how to approach evaluating oil spill conditions.

The first incident was Sept. 3, 2015 when two tow barges collided on the Lower Mississippi River near Columbus, Kentucky. The second was Jan. 21, 2016 when a barge towed by the UTV Amy Frances struck the Natchez Bridge on the Lower Mississippi River. The Lower Mississippi is the most traveled and commercially important portion of the river’s system.
Induced Polarization Associates, LLC was formed to explore the commercial applications of Marine Induced Polarization

- Proven technology relating to hydrocarbon detection
- Investigating the practicality of applications which benefit the oil spill community
A Brief History...

• Induced Polarization (IP) has been used on land for more than a half-century, its initial application aimed at mining for precious metals.

• Recently the focus has been on detection of hydrocarbons and associated derivatives in the water column, on sea and river beds, or sequestered in bottom sediments.

• Measurement of non-floating oil substances, both from industrial sources and collected weather-altered field samples, have been tested with similar positive results.
How it works

- Sediment
- Oil
- Depressor
- Transmit Electrodes
- Receiver Electrodes

Diagram showing the flow of oil through sediment, with depressor, transmit electrodes, and receiver electrodes indicated.
How it works

• A controlled electrical current is introduced into sea/river water
• The resulting voltage developed between paired receiver electrodes is acquired
How it works

• Acts as a capacitor

• The phase shifts between the current and the voltage are used to identify anomalies, such as hydrocarbons.
How it works

Specifications

• Salinity: Sea Water, Rivers, Lakes
• Minimum Temperature (°C): -2
• In laboratory, detection of oil down to 2 ppm
• Current cable configuration:
  ➢ Total length: 160m
  ➢ Weight: ~150 lbs.
• Cable’s breaking strength: 6500 lbs.
• Water depth: 1m to Full Ocean Depth
• Penetration in sediment: Down to 20m
  ➢ Transmitter/receiver geometries are adjustable
  ➢ The distance between receiver electrode pairs determines depth of penetration.
Seawater Field Measurements:

South Africa

• Commercial marine IP survey in South Africa

• Discovered 2 large & hidden placer titanium deposits

• Invisible to ROV or diver

• Survey area: 3.5km x 11km

• 25-day survey with 100m line spacing
Seawater Field Measurements: Wycoff

• Field trials were conducted at the Wyckoff superfund site in Puget Sound, WA (2016)

• Former creosote manufacturing facility

• Pockets of creosote/tar, NAPL and PAH have either been capped and are randomly extruded to the seabed and/or transported to the intertidal zones
Seawater Field Measurements: Wycoff

Comparison Check:
EPA TarGOST Survey Results

...AND we get anomalies at the same places.

Replication Check:
Wykoff Site Comparative Survey Plots

16 August 2016
12 December 2016
Freshwater Field Measurements: Lake Washington

- Field trials were conducted at the Quendall Terminals superfund site in Lake Washington, WA (2017)
- Former creosote manufacturing facility
Field Operations

Deployment & Recovery

Vessel requirements
- Minimum 25 ft.
- Protected area for electronics
- 4 x 8 ft. deck space
- Ability to travel <= 3 kts

Hand Deployment

Cable being towed

Hand Recovery
Field Operations
Data acquisition
Field Operations

Data products

• Data files
  • *.txt
  • *.csv
  • *.xls
  • 3D Voxels
  • & Others

• Graphics files
  • Georeferenced maps
  • *.KMZ
  • Shapefiles
  • & Others
How can Marine IP be useful for Oil Spills?

- Baseline Characterization
- Offshore Spill Response
- Nearshore, River, Fresh Water Incidents
- Legacy Spills
- Potential for Plastics
Baseline Assessments – Categorizing Environmental Liability

- Mapping of existing oil seeps
  - Extent & Location of existing source releases
- Pre-existing contaminations
  - Prior E&P activity
  - Adjacent operators: source contamination potential

How can Marine IP be useful for Oil Spills?
Spill Response

- Mapping of Oil in/on Sediment

- Potential: 3D Mapping of water column
  - Real-time data returns of extent

- Potential: Monitoring the movement of spill
  - Confirm validity of Trajectory Modeling

- Potential: Shoreline Incursion “ALARM”
  - Near-shore / Sensitive Area Warning System
How can Marine IP be useful for Oil Spills?

**Nearshore, River, Freshwater Incident Response**

- IP is capable of strong signal returns in fresh & brackish water environments
  - Pipeline river crossings – leak detection
  - Static monitoring at inflows / outflows
  - Spill response/monitoring in shallow river deltas
Impact Assessments and Legacy Spills

- Identification of Location & Extent of Contaminated and Uncontaminated Areas
  - Single towed cable + detection into sediment = efficient mapping
  - Fills in otherwise interpolated areas between cores
  - Enables targeted & reduced sediment sampling

Example: Survey of Wycoff legacy contaminated site
Marine IP Applications

**Plastics**

- IPA has made *preliminary* lab measurements suggesting some plastics react to Induced Polarization techniques

- Potential Applications:
  - Microplastics detection & mapping
  - Marine debris at sea
  - Nearshore contaminations
    - Reef & other underwater critical habitats
    - Sensitive Areas: Estuaries, Refuges

- Further possibilities:
  - Lab testing is required for expanded sample sets

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<table>
<thead>
<tr>
<th>Plastic</th>
<th>Dielectric Strength</th>
<th>Dielectric Constant</th>
<th>Dissipation Factor</th>
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<tbody>
<tr>
<td>Abbreviation</td>
<td>Chemical Name</td>
<td>@ 1KHz</td>
<td>@ 1MHz</td>
</tr>
<tr>
<td>ECTFE (ethylene chlorotrifluoroethylene copolymer)</td>
<td>5000</td>
<td>2.6</td>
<td>2.6</td>
</tr>
<tr>
<td>ETFE (ethylene tetrafluoroethylene copolymer) Tefzel</td>
<td>6250</td>
<td>5000</td>
<td>2.6</td>
</tr>
<tr>
<td>FEP (fluorinated ethylene-propylene copolymer) Teflon FEP</td>
<td>6500</td>
<td>2000</td>
<td>2.05</td>
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<tr>
<td>PFA (perfluoroalkoxy) Teflon PFA</td>
<td>4000</td>
<td>6250</td>
<td>2.1</td>
</tr>
<tr>
<td>PCTFE (polychlorotrifluoroethylene)</td>
<td>3000</td>
<td>2700</td>
<td>2.3</td>
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<tr>
<td>PTFE (polytetrafluoroethylene) Teflon</td>
<td>2200</td>
<td>1000</td>
<td>2</td>
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<tr>
<td>PVF (polyvinylfluoride) Tedlar</td>
<td>3500</td>
<td>1700</td>
<td>8.5</td>
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<tr>
<td>PVDF (polyvinylidenefluoride) Kynar</td>
<td>6950</td>
<td>1300</td>
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<tr>
<td>PC (polycarbonate) Lexan</td>
<td>6300</td>
<td>2000</td>
<td>2.99</td>
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<tr>
<td>PET (polyethyleneterephthalate) Mylar</td>
<td>7500</td>
<td>3400</td>
<td>3.2</td>
</tr>
<tr>
<td>LDPE (low density polyethylene)</td>
<td>5000</td>
<td>3000</td>
<td>2.2</td>
</tr>
<tr>
<td>LLDPE (linear low density polyethylene)</td>
<td>5000</td>
<td>3000</td>
<td>2.2</td>
</tr>
<tr>
<td>HDPE (high density polyethylene)</td>
<td>5000</td>
<td>3000</td>
<td>2.3</td>
</tr>
<tr>
<td>UHMWPE (ultra high molecular weight polyethylene) (0.010”)</td>
<td>1300</td>
<td>1300</td>
<td>2.3</td>
</tr>
<tr>
<td>PI (polyimide)</td>
<td>7000</td>
<td>3600</td>
<td>3.5</td>
</tr>
<tr>
<td>PMMA (polymethylmethacrylate) Plexiglas</td>
<td>4</td>
<td>3.5</td>
<td></td>
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<tr>
<td>PP (polypropylene)</td>
<td>8000</td>
<td>2700</td>
<td>2.2</td>
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<tr>
<td>PS (polystyrene) Styron</td>
<td>5000</td>
<td>5000</td>
<td>2.7</td>
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<td>PVC (polyvinylchloride)</td>
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<td>3</td>
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<tr>
<td>PVDC (polyvinylidenechloride) Saran</td>
<td>4.5</td>
<td>4</td>
<td></td>
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<tr>
<td>PI (polyimide)</td>
<td>7000</td>
<td>3600</td>
<td>3.5</td>
</tr>
</tbody>
</table>

Table A: Dielectric properties of various plastics
## Comparative Analysis – Level of Effort

### Marine IP v. Coring in potentially contaminated soils

**Example Survey: Contaminant Delineation of Quendall Terminals Superfund Site**

- **Survey Efficiency:** Able to identify extent of contaminated AND non-contaminated areas
  
  = *Efficient, cost-effective, & fast understanding of delineation & extent*
  
- **Rate of Collection:** Provides verifiable results with reduced vessel costs, significant reduction of expensive chem analyses, chain-of-custody challenges, etc.

### Survey Methodology:

<table>
<thead>
<tr>
<th></th>
<th>Marine IP</th>
<th>Coring</th>
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<tbody>
<tr>
<td><strong>Survey Days:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Marine IP Survey</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Sediment Sampling Days</td>
<td>2</td>
<td>18 (estimated for 12 coring, 6 grabs)</td>
</tr>
<tr>
<td>Total Vessel Survey Days</td>
<td>3</td>
<td>18</td>
</tr>
<tr>
<td><strong>Data Collection:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td># of Samples</td>
<td>38</td>
<td>350</td>
</tr>
<tr>
<td><strong>Sediment Chemistry:</strong></td>
<td>$7,920</td>
<td>$84,000</td>
</tr>
</tbody>
</table>

**Note:** Costs are **ESTIMATES** only for exhibiting efficiencies of Marine IP system

**Survey Area:** 0.1km² (.3km x .4km)

**Assumptions:** Cores/day = 6; grabs/day = 20; Samples/Core = 4; Lab Chemistry: $240/sample

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**Proprietary Information – Company Confidential**

**Induced Polarization Associates, LLC**
Potential Future Developments

Fueling & Port Monitoring
• Shipping fueling ops
• ‘Smart Boom’: instant alert to leaks
• Improper ballast discharges

Static Mounts (e.g.: Buoys)
• Detection In specific targeted areas
• High-fidelity modeling when used in unison

Rig Mounts
• Immediate Leak Detection
• Potential for other identifications:
  (e.g.: For regulatory compliance)
  □ Sewer/effluent discharge
  □ Operating fluids
  □ Other contaminants (polarizable)
Advantages

• Compliant with USCG/OSRO guideline with respect to non-floating oil
• Unique in its ability to detect hydrocarbons in the water column, river/seabed and embedded in sediments
• Highly robust and ruggedized
• Easily transportable: small instrument foot print can be mobilized on a vessel of opportunity as small as 25-ft
• Small environmental footprint: In bottom reference mode bottom disturbance no greater than medium sized flat fish.
• On-the-fly interpretable real time displays
  • Fast output a layered geo-plot for onsite
  • Potentially detect and locate leaky outfalls and pipelines
Limitations

• Not optimal for sea surface detections
• Current signature library is still limited, though expanding
• Effect of biofouling on static arrays unknown (primarily a receiver dipole design issue)
Conclusions

• Marine IP is an efficient tool for detection & mapping of non-floating hydrocarbons

• Field-verified technology

• During an incident or for legacy spills, marine IP:
  • provides a more complete georeferenced data set
  • enables more targeted sediment sampling, reducing costs

• Potential to detect & map oil in water column during incidents

• Potential for oil spill monitoring and early-warning alerts:
  • Ports and Docks
  • Pipeline leaks
  • Intakes, sensitive areas
Thank you!

For more information:
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