Efficient Remediation
Utilizing Optimized, Low Cost Oxidizers

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Hepure Product Line

- ZVI Reactive Iron Powders
- Bioremediation
- Chemical Oxidants
- Metals Treatment
- Case Studies
CHEMICAL OXIDANTS

Potassium Permanganate, 97% Solid

Sodium Permanganate, 40% Solution

Hepure Pure-Ox
Successful Chemical Oxidation

1. Accurate assessment, especially source area
2. Must be effective for a full range of contaminants, such as MTBE and 1,4 Dioxane
3. Make contact and allow time for reaction
4. Reactivity: Last consideration

Petroleum Hydrocarbons
BENEFITS OF Pure-Ox

- **Rapid degradation**
- **Persistence**
- **Pure- no metals/minerals**
- **No activation needed**
- **ISCO NAPL**
- **Low heat production**
- **Leads into MNA**
Pure-Ox Chemistry

Pure-Ox is a robust chemistry ISCO process with a high oxidation potential for contaminant destruction.

Generates high levels of hydroxyl radical, superoxide radical, and hydroperoxide anion.

Pure-Ox can destroy nearly all environmental contaminants of concern and provide enhanced treatment of adsorbed contaminants and nonaqueous phase liquids (NAPLs).

\[
2\text{OH}^- + 2\text{H}^+ + 2e^- \rightarrow 2\text{H}_2\text{O} \quad \text{E}^\circ = 2.76\text{v}
\]

\[
\text{H}_2\text{O}_2 + 2\text{H}^+ + 2e^- \rightarrow 2\text{H}_2\text{O} \quad \text{E}^\circ = 1.77\text{v}
\]

\[
\text{HO}_2 + \text{H}_2\text{O} + 2e^- \rightarrow 3\text{OH}^- \quad \text{E}^\circ = 0.88\text{v}
\]
Pure-Ox Applications
Bore Hole and Well Applications
Pure-Ox Treatability

Relative Treatability

- PFOS
- PFOA
- 1,4 Dioxane
- Toluene
- MTBE
- Xylenes
- Ethylbenzene
- Benzene
- Polycyclic Aromatic Hydrocarbons

ESTCP Project ER-200632
Pure-Ox robust chemistry

- high oxidation potential for contaminant destruction
- take advantage of natural occurring catalysts, iron, manganese, sulfur..
Pure-Ox Reactivity

- Pure-Ox generates high levels of hydroxyl radical, superoxide radical, and hydroperoxide anion,
- Pure-Ox can destroy nearly all environmental contaminants of concern and provide enhanced treatment of adsorbed contaminants and nonaqueous phase liquids (NAPLs).
Pure-Ox Application

- Pure-Ox is applied as a dilute solution,
  - increasing ROI and allow for
  - reactions in the vadose zone
  - chemically controlled longevity
Keys to Success

- Inject a design amount of oxidant
- Use a smaller ROI, <10’
- Direct push is better than wells
- Plan multiple events, attack source area
- Insure compatible soils, sand good, clay bad
Pure-OX AVAILABILITY

Standard Packaging

<3000 Gallons

55 gallon drums

275 gallon totes

Custom Packaging

>3000 Gallons

Tanker
<table>
<thead>
<tr>
<th>Hepure Chemical Name</th>
<th>Generic Product Name</th>
<th>Container Types</th>
<th>Concentration of Application</th>
<th>Typical Use for Remediation</th>
<th>Container Weight</th>
<th>Suggested Unit Price (lb)</th>
<th>Estimated Shipping 1000 Miles</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ferox PRB</td>
<td>Zero Valent Iron</td>
<td>Super Sack</td>
<td>Shurry @ 4-10 lb/gal</td>
<td>abiotic reduction of solvents, precipitation of metals and nitrates</td>
<td>2205 lb</td>
<td>$0.55</td>
<td>$700</td>
</tr>
<tr>
<td>Ferox Flow</td>
<td>Zero Valent Iron</td>
<td>Super Sack</td>
<td>Shurry @ 4-10 lb/gal</td>
<td>abiotic reduction of solvents, precipitation of metals and nitrates</td>
<td>2205 lb</td>
<td>$0.75</td>
<td>$700</td>
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<tr>
<td>Ferox Target</td>
<td>Zero Valent Iron</td>
<td>Super Sack</td>
<td>Shurry @ 4-10 lb/gal</td>
<td>abiotic reduction of solvents, precipitation of metals and nitrates</td>
<td>2205 lb</td>
<td>$1.20</td>
<td>$700</td>
</tr>
<tr>
<td>Ferox Plus</td>
<td>eZVI</td>
<td>275 gal Tote</td>
<td>ready to inject</td>
<td>abiotic reduction of solvents, precipitation of metals and nitrates</td>
<td>3120 lb</td>
<td>$2.05</td>
<td>$800</td>
</tr>
<tr>
<td>Sodium Permanganate</td>
<td>40% NaMnO₄</td>
<td>55 gal Drum</td>
<td>1% to 40% Solution</td>
<td>oxidation of chlorinated solvents</td>
<td>620 lb</td>
<td>$2.45</td>
<td>$700</td>
</tr>
<tr>
<td>Potassium Permanganate</td>
<td>KMnO₄</td>
<td>5 gal bucket</td>
<td>1% to 5% Solution</td>
<td>oxidation of chlorinated solvents</td>
<td>55 lb</td>
<td>$2.45</td>
<td>$700</td>
</tr>
<tr>
<td>1.5&quot; Permanganate Candle</td>
<td>Potassium Permanganate</td>
<td>each 1.35&quot; x 24&quot;</td>
<td>Ready to Use</td>
<td>slow release permanganate for chlorinated solvents</td>
<td>5 lb</td>
<td>$100.00 each</td>
<td>$550</td>
</tr>
<tr>
<td>2.5&quot; Permanganate Candle</td>
<td>Potassium Permanganate</td>
<td>each 2.5&quot; x 24&quot;</td>
<td>Ready to Use</td>
<td>slow release permanganate for chlorinated solvents</td>
<td>7.5 lb</td>
<td>$200.00 each</td>
<td>$550</td>
</tr>
<tr>
<td>1.5&quot; Reusable Holder</td>
<td>PVC 40</td>
<td>each 1.5&quot; x 24&quot;</td>
<td>Ready to Use</td>
<td>In well deployment of 1.5&quot; Permanganate Candle (Reusable)</td>
<td>2 lb</td>
<td>$80.00 each</td>
<td>$550</td>
</tr>
<tr>
<td>2.5&quot; Reusable Holder</td>
<td>PVC 40</td>
<td>each 3&quot; x 24&quot;</td>
<td>Ready to Use</td>
<td>In well deployment of 2.5&quot; Permanganate Candle (Reusable)</td>
<td>5 lb</td>
<td>$120.00 each</td>
<td>$550</td>
</tr>
<tr>
<td>Hydrogen Peroxide</td>
<td>30% H₂O₂</td>
<td>55 gal Drum</td>
<td>2% to 20% Solution</td>
<td>oxidation and biological treatment of petroleum hydrocarbons</td>
<td>500 lb</td>
<td>$0.40</td>
<td>$700</td>
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<tr>
<td>Calcium Peroxide</td>
<td>Calcium Peroxide</td>
<td>55 lb bags</td>
<td>10 - 40 gram/L</td>
<td>oxygen amendment for biological treatment of petroleum hydrocarbons</td>
<td>55 lb</td>
<td>$2.90</td>
<td>$700</td>
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<tr>
<td>Remoxo</td>
<td>Calcium Polysulfide</td>
<td>55 gal Drum</td>
<td>10 - 40 gram/L</td>
<td>Stabilization of Metals</td>
<td>583</td>
<td>$0.51</td>
<td>$700</td>
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<tr>
<td>Ferric Sulfate</td>
<td>Ferric Sulfate</td>
<td>55 lb bags</td>
<td>1 - 5 gram/L</td>
<td>abiotic reduction of solvents, precipitation of metals and nitrates</td>
<td>55 lb</td>
<td>$0.95</td>
<td>$450</td>
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<tr>
<td>Sodium Hydroxide</td>
<td>25% NaOH</td>
<td>55 gal Drum</td>
<td>10 - 40 gram/L</td>
<td>pH amendment for anaerobic biological treatment of chlorinated compounds</td>
<td>560 lb</td>
<td>$0.32</td>
<td>$500</td>
</tr>
<tr>
<td>Renewal - SD</td>
<td>60% Emulsified Vegetable Oil</td>
<td>5 gal bucket</td>
<td>ready to inject</td>
<td>anaerobic biological treatment of chlorinated compounds</td>
<td>40 lb</td>
<td>$1.30</td>
<td>$700</td>
</tr>
<tr>
<td>DHC</td>
<td>Dehalococcosides</td>
<td>19 L Keg</td>
<td>Mix w/ injectants Dihate 10 g/l</td>
<td>microbial amendment for treatment of chlorinated compounds</td>
<td>1 L</td>
<td>$177.00</td>
<td>$290 (19L Keg)</td>
</tr>
<tr>
<td>Lactate</td>
<td>Lactate</td>
<td>55 gal Drum</td>
<td>ready to inject</td>
<td>anaerobic biological treatment of chlorinated compounds</td>
<td>605 lb</td>
<td>$1.25</td>
<td>$700</td>
</tr>
</tbody>
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