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A Brief Introduction to the iSOC™ Technology

Bioremediation	<ul style="list-style-type: none"> • Since the mid-1990's pure oxygen to enhance natural attenuation has been growing as a remediation technology. • Today there are a variety of technologies that can provide low to moderate concentrations (10-20 ppm) of DO. • As these elevated DO levels mix with contaminated ground water, natural biodegradation occurs (due to existing in situ micro-organisms). • Unfortunately, technologies such as sparging, chemical oxidation and powdered peroxide compounds is not effective in low permeability sites.
inVentures Technologies, Incorporated	<ul style="list-style-type: none"> • iSOC™ developed inVentures Technologies Incorporated. • inVentures developed mass transfer technology....where they can transfer any gas into a liquid. • Offices in Ontario and Fredericton, NB. • Started by three PE's (Graduates of Univ. Of Waterloo). • John Archibald is the Managing Partner.
iSOC™ History	<ul style="list-style-type: none"> • Today over 175 sites in 30 states (Since 2001). • iSOC installation are occurring monthly. • The European market this year may out perform the US market. • Several state regulators and national companies are actively using iSOC.
What is iSOC™?	<ul style="list-style-type: none"> • It is a gas delivery technology that will infuse any gas into a liquid. • iSOC™, stands for "in situ submerged oxygen curtain". • It is a low cost technology for enhancing natural attenuation.
How does it work?	<ul style="list-style-type: none"> • iSOC™ contains over 700 hydrophobic microporous hollow fibers that allow for the mass transfer of oxygen into the ground water. • The technology supersaturates the ground water with low decay D.O. at concentrations ranging from 40 to 200 ppm depending on aquifer conditions and depth of injection. • The oxygen transfer efficiency is nearly a 100%. • The underlying scientific principle for the <i>iSOC™</i> is the equilibrium that exists between the dissolved concentration of a gas in a liquid and the partial pressure of the gas above the liquid. Henry's Law states: the weight of any gas that will dissolve in a given volume of liquid is directly proportional to the pressure that the gas exerts above the liquid.

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iSOC™ Has So Many Advantages

Distinguishing Features	<ul style="list-style-type: none"> • Will infuse any gas into a liquid. • No moving parts and does not require electricity. • Very low O & M. • Easily moved to a new injection point or new site. • Works in a 2 inch monitoring well or larger. • Powered by the pressure of the gas in the cylinder. • Installation compound aboveground or below ground. 					
Construction	<ul style="list-style-type: none"> • The iSOC™ unit measures 1.62 inches by 15 inches. • The control panels measures: (Single 3 x 9 x 8); (Triple 3 x 21 x 8). • Made of stainless steel. 					
Connecting Tube	<ul style="list-style-type: none"> • ¼ inch polyurethane tube connects iSOC, control panel and gas cylinder. 					
Site Compatibility	<ul style="list-style-type: none"> • Primary remediation strategy to attack the source. • Polish off low level contaminated sites. • Curtain to stop off-site plume migration. • Can be used on petroleum or chlorinated solvents. • Not bothered by high levels of iron, BOD₅ or COD. 					
Radius of Influence	<ul style="list-style-type: none"> • Typically 10-15 feet: Higher in tight soils due to molecular diffusion. • Primarily depends on ground water velocity and the oxygen demands of the aquifer. • Installs at any depth (deeper the water column the higher the DO level). • Infuses 4 to 10 times more dissolved gas than any competitive technology. 					
What Determines DO levels?	<ul style="list-style-type: none"> • Atmospheric Pressure Determines DO Levels. • iSOC™ will deliver about 41 PPM of dissolved oxygen per atmosphere of head pressure (on the iSOC™ unit). • Example: A 33-foot column of water would equal about 2 atmospheres. (1 atm = 14.7 psi; plus the water head pressure (2.306 ÷ 33) = 14.31 total pressure, or 29 psi, or about 2 atmospheres. 2 atm x 41 PPM = 82 PPM DO in 33 foot column). 					
DO Levels	Gas Type	Water Depth in Feet				
		5'	10'	15'	20'	50'
	Oxygen	42	55	62	69	111
	Methane	22	30	33	37	59
	Propane	66	88	99	110	175
	Hydrogen	2	2	3	3	5
	Ethane	57	75	85	95	150



What Makes the iSOC™ Work?

Control Panel	<ul style="list-style-type: none"> • Single and Triple Control Panels. • Inlet pressure gauge; outlet pressure gauge; flowmeter; release valve. • Made of stainless steel construction. • All components oxygen cleaned. • Comes pressure tested from the factory.
Barb Fittings	<ul style="list-style-type: none"> • Barb fitting on the panel & iSOC (0.110 ID and 0.195" OD). • Rated for pressures up to 110 PSI (when using 1/4" OD tubing). • To remove (pinch off with pliers).
iSOC Tubing	<ul style="list-style-type: none"> • Connect Control Panel and iSOC unit (0.25" OD and a 0.17 ID). • Use polyurethane tubing only (clear or natural). • Same tubing connects all equipment (regulator; control panel; iSOC unit).
Polyurethane Tubing	<ul style="list-style-type: none"> • Kink-proof; broad resistance to chemicals, water, fuel, oil and fungus. • Not affected by oxygen. • Flexible; recommended for use with 360 style ring-barbs • Pressure rating of 145 psi @ 60 deg.C. • Temperature range is -20 to + 60 degree C.
Lifting Wire	<ul style="list-style-type: none"> • Use rubber coated wire or heavy strength twine.
Turning The System On	<ul style="list-style-type: none"> • Attach regulator to the Cylinder. • Attach tubing to 1) regulator, 2) control panel and 3) iSOC probe. • Calculate injection well head pressure and open cylinder. • Adjust flowmeter. • Test for leaks (only use Snoop). • Place iSOC unit in the well.



iSOC™ Can Infuse Any Gas Into a Liquid

Gas Regulator	<ul style="list-style-type: none"> • Use two-stage low flow regulator (0-50 psi) for each gas cylinder. • Retrofit regulator with iSOC barb fitting. • Two stage regulator used for maintaining constant pressure flow. • Can save money by utilizing a manifold to pigtail 2-4 gas cylinders.
Gas Cylinders	<ul style="list-style-type: none"> • You will need one gas cylinder for each control panel. • Can use manifold for multiple gas cylinders or control panels.
Oxygen Consumption	<ul style="list-style-type: none"> • When using oxygen, set each flowmeter to 15cc per minute. • The flowmeter setting varies for other gases. • Calculation: 15 cc/min per iSOC unit x 1440min/day = 21,600 cc/day. 1cubic foot of oxygen = 28,000 cc. Divide 28,000 into 21,600. 1-iSOC will use .77 cubic feet of oxygen per day.
How Long Gas Cylinders Will Last?	<ul style="list-style-type: none"> • 40 cu. ft cylinder (7 x 18) will last approximately 50 days/per iSOC™ • 80 cu. ft cylinder (7 x 32) will last approximately 100 days/per iSOC™ • 150 cu. ft cylinder (8 x 48) will last approximately 194 days/per iSOC™ • 220 cu. ft cylinder (9 x 51) will last approximately 280 days/per iSOC™



What Are The Equipment Cost?

Equipment provided by inVentures Technologies Incorporated	
iSOC[®] Unit	<ul style="list-style-type: none"> • Each unit sells for US\$3500. • Rent: US\$300/month (minimum: 3 iSOCs & 6-month rental agreement). • Plus shipping costs.
iSOC[™] Control Panel	<ul style="list-style-type: none"> • Single control panel (\$750.00). • Triple control panel (\$1250.00). • Plus shipping costs
Vendor Equipment Needed	
Gas Regulator	<ul style="list-style-type: none"> • Retail for \$295 each. (Victor #270)– Call EBS at 415-381-5195 • Use iSOC barb fitting supplied by inVentures Technologies.
Gas Cylinder	<ul style="list-style-type: none"> • Rental is usually about \$19.00 to \$49/month, depending on size. Order through EBS (415-381-5195)
Polyurethane Tubing	<ul style="list-style-type: none"> • EBS supplies the specific ¼” OD polyurethane tubing. Price ranges from \$0.35 to \$0.50/per foot. It comes in 100 M and 500 M spools with 10 connectors.
Storage Compound	<ul style="list-style-type: none"> • Above ground building or shed. Call EBS 415-381-5195 for the MECO gas sheds \$1,500 each plus shipping and handling. • Below ground vaults (3x3x3 is best).
High Range DO Meter	<ul style="list-style-type: none"> • DO meter to read the high range DO (40-200 ppm). • “The OxyGuard Handy” measures both ppm (mg/l) and % of saturation. They sell for around \$900.00 and can be used on multiple sites. EBS sells the Point Four meters.
Services Provided by Environmental Consultant	
Before iSOC[™] Installation	<p>1) RAP, 2) injection wells, 3) sampling, 4) trenching, 5) paving, 6) conduit for tubing, 7) hanging brackets or screws for control panel and iSOC and 8) installation compound (aboveground shed or underground vault), 9) O & M.</p>



Simple Installation and Startup Procedures

Step 1	Attach gas regulator to cylinder. (Use correct iSOC fitting)
Step 2	Connect the gas regulator/cylinder to inlet gauge on control panel.
Step 3	Attach polyurethane tubing to outlet gauge on control panel.
Step 4	Attach opposite end of tubing (in Step 3) to iSOC unit.
Step 5	Attach lifting wire to iSOC unit.
Step 6	Calculate the well head pressure (Divide 2.306 into the column of water)
Step 7	Turn the regulator knob counterclockwise so the pressure is near zero.
Step 8	Open gas valve on the cylinder.
Step 9	Open regulator: (until inlet gas gauge is 4-5 PSI above the well head pressure.
Step 10	Open the flowmeter on the control panel to approximately 30 cc.
Step 11	Press release valve on the control panel for 6-8 seconds to purge the lines.
Step 12	Place the iSOC probe in a five gallon bucket of water.
Step 13	Adjust flowmeter to 20 cc. (Look for one bubble every 1-2 seconds coming from the top side of the iSOC.
Step 14	Use Snoop to leak test all exposed fittings. Make sure no leaks where the tube is attached to the top of the iSOC. (Repair all leaks before continuing).
Step 15	You are now ready to lower the iSOC into the well (slowly). Do not allow lifting wire and tube to wrap around each other as the iSOC is lowered into the well.
Step 16	Monitor outlet gas gauge for the next 20-30 minutes. (It should reflect well head pressure, or target depth of the iSOC. (Hit bypass valve for 1-2 seconds after the iSOC has been lowered into the well to reduce wait time).
Step 17	When finished, it is best to leave the flowmeter set between 18-20 cc for the first 24 hours. (Recommended operating flow is 15cc).



iSOC Testing Parameters (For Petroleum Hydrocarbon Sites)

Field Parameters	
Dissolved oxygen (DO)	Identifies aerobic and anaerobic regions of contaminated site and the chemical, physical and biochemical activities occurring. (Low dissolved oxygen levels can limit the bacterial metabolism of certain organic compounds).
pH	Identifies the acidity or alkalinity of water. A change in pH may be associated with microbial activity. The optimum pH for bioremediation is 4-9;
Temperature	Optimal soil and water temperatures are 10° to 40°C
Conductivity	Conductivity is a good measure of the total amount of salts in solution (e.g., calcium, magnesium, sodium, potassium, , chloride, and others).
Turbidity	Checks for suspended and colloidal matter such as clay, silt, finely divided organic and inorganic matter, and microscopic organisms.
Redox Potential (ORP)	To determine if aerobic (more positive oxidizing conditions) or anaerobic (more negative reducing conditions) are present
Biological Oxygen Demand (BOD)	Measures the amount of oxygen consumed by microorganisms in decomposing organic matter.
Laboratory Parameters – EBS provides these microbiological studies and bench tests.	
VOCs	Determine baseline level of contamination and relative concentrations of contaminants.
Salinity	Elevated salinity may reduce microbial activity.
Nitrate	Essential nutrient for bioremediation.
Total Inorganic Carbons (TIC) (Alkalinity)	Best overall indicator of aerobic biological activity (by measuring the generation of CO ₂).
Total Organic Carbons (TOC)	Measure of the total amount of natural organic material in a water sample.
Total Dissolved Solids (TDS)	Defines the concentration of dissolved organic and inorganic chemicals.
Heterotrophic Plate Count	Procedure for estimating the number of live heterotrophic bacteria in the water. (Colony Forming Units). Another good indicator of biodegradation.



iSOC™ Performance

<p>BPAmoco Site Maple Shades, NJ</p>	<ul style="list-style-type: none"> • Approximately 3 months after installation, an effective barrier of dissolved oxygen was established. • Significant reductions in MTBE (up to 84%), TBA (31%) and benzene (73%) downgradient of the oxygen barrier. • Gasoline constituents reduced 95-100% within 10 months of installation. • Pilot study ran 132 days. • Heterotrophic bacteria plate count increased in from 470-8000%. • Elevated levels of ferrous iron, BOD & COD did not inhibit aerobic degradation.
<p>Englewood, Colorado</p>	<ul style="list-style-type: none"> • Site had moderate levels of benzene (5200 ppb) and high levels of MTBE (nearly 490,000 ppb). • The 2-acre commercial site is composed of silt and clay deposits down to a depth of approximately 40 feet. • The water table is found at a depth of nearly 35 feet. • The ground water contamination from a former UST had created a plume nearly 200 feet long. • A total of 6 iSOCs were placed approximately 10-15 feet up gradient of wells with the highest levels of contamination. • During system operation, the dissolved oxygen in each of the injection wells has ranged from 45-60 ppm. • After 6 months of full operation of the iSOC system, the dissolved oxygen throughout the most highly contaminated part of the site was maintained at 0.5 to 1.5 ppm. • Benzene concentrations across the entire area have been reduced by between 73% and 100% over 6 months. • MTBE concentrations in every well but two have been reduced from 66% to 100%. • Between March and June, 2003 when area draught conditions were relieved by heavy precipitation, the water table across the site rose approximately 3 feet. • During this time, little seasonal rebound of petroleum constituents occurred and levels of contamination continued to decline sharply.
<p>FDOT Site Tallahassee, FL</p>	<ul style="list-style-type: none"> • Groundwater and soil contamination was caused by a former underground storage tank (UST) at this active farm facility. • iSOC was implemented after 4 years of MPE was successful to recover free product and a significant amount of hydrocarbon mass. • However, the tight clay formation and the depth of contamination to 190 feet within a sinkhole feature limited the success of this remedial technology. • First quarter monitoring data indicates a 65% reduction in groundwater concentration in monitor wells located 10 feet away from isoc wells. • First order decay rates indicate that the time to cleanup has been reduced by six years by switching to the iSOC™ enhanced bioremediation system.



2003 iSOC™ Presentations and Conferences

March	Environmental Technology Symposium and Workshop, Charlotte (Mar 24-28)
June	Battelle Bioremediation Conference, Orlando, FL (June 2-5)
June	<p>NGWA MTBE Focus Conference, Baltimore (June 5-6)</p> <ul style="list-style-type: none"> ▪ <i>In situ Remediation of an MTBE and BTEX Groundwater Plume Using a Full-Scale Oxygen Infusion System</i> Sunoco, Inc. and Handex Environmental ▪ <i>Pilot Study to Evaluate Effectiveness of Oxygen Infusion Technology to Bioremediate MTBE and TBA in Ground Water</i> BP Amoco, Inc. and Handex Environmental ▪ <i>Enhanced Natural Attenuation of MTBE and TBA in Ground Water at a High Dissolved Iron Site in the Northeast US Using iSOC Technology</i> Global Technologies and inVentures Technologies
August	NGWA Petroleum Hydrocarbons Conference, Costa Mesa, CA (August 20-22)
October	UMass Contaminated Soils and Water Conference, Amherst, MA (October 20-23)
November	NGWA Remediation Conference: Site Closure and the Cost of Cleanup, New Orleans, LA (November 13-14)
November	Florida Remediation Conference, Orlando (November 20-21)



iSOC™ is an innovative technology

Versatile	<ul style="list-style-type: none">• Use to treat source, polish off sites or to stop off-site migration.• Will infuse any gas (oxygen, propane, methane, hydrogen, ethane).• Can be used for cometabolic treatment (with alkane gases).
Portable	<ul style="list-style-type: none">• No moving parts and no electricity.• Easily moved to a new injection point or new site• Installs in existing two inch monitoring wells (or larger).
Affordable	<ul style="list-style-type: none">• Annual cost of oxygen for 3-iSOCs is less than \$250.00 a year.• Lowest annual O & M of any competitive technology.• True pay-for-performance technology for cleaning up sites.• Installs in a few hours and is extremely easy to use.• The iSOC™ unit will last for several years.
Effective	<ul style="list-style-type: none">• Can deliver 40-200 ppm of dissolved oxygen into the ground water.• Is 4-10 times more effective than any competitive technology.• Oxygen transfer efficiency is nearly a 100%.

- **iSOC™ is now operating on more than 175 sites in more than 30 states.**
- **It is the best technology for enhancing natural attenuation.**
- **It has the lowest O & M of any bioremediation technology.**