Safety Considerations with Hydrogen

Introduction:

This document is a summary of the safety considerations that must be given when using iSOC® to infuse H_2 into groundwater. inVentures Technologies inc. does not accept responsibility for any damages arising from the use of hydrogen or any other compressed gases with the iSOC®. Remediation system using the iSOC® must be designed and approved by a qualified professional engineer considering all necessary and appropriate safety considerations and engineering specifications.

Safety Considerations:

Hydrogen is flammable and displaces oxygen, resulting in hazards of explosions, fires and anoxia. Hydrogen has specific properties that must be taken into considerations. It leaks easily due to the small size of its molecules; it is easily ignited, even by small static discharges; its flame is colourless; it burns rapidly and emits little heat (10% of the heat from hydrocarbons per comparable unit of energy); it forms flammable mixtures with air in a wide range of concentration (mixtures between 4% and 75% are flammable). Any cylinder containing a gas mixture greater than 2% Hydrogen is considered flammable. Since 2% H_2 is not likely to be enough partial pressure for bioremediation, an iSOC® system that uses hydrogen shall be designed to address issues of:

1. Leak prevention and detection

- Upon commissioning and maintenance, the system should be tested for leaks at all joints using appropriate gas detection methods, such as using the soapy solution to test fitting connections and using a lower explosion limit (LEL) detector to measure combustible gas content in the air.

2. Storage and ventilation of enclosed shelters and rooms

- Ideally, cylinders, gas lines and treatment wells shall be installed outdoors, protected from tampering, damage, corrosion, and if possible, severe weather (freezing rain, heavy snowfalls). An example for cylinder storage may be a chain-linked fence structure with a roof.

- If the cylinder is stored in a room or if piping/tubing containing flammable hydrogen runs through a room, the room is considered a classified area. Any electrical devices in this room mush comply with Electrical Codes (CSA C22.1 Canadian Electrical Code and NFPA 70 National Electrical Code) for Class 1, Zone1 and Group 2C. The top portion of the classified area is to be well ventilated.

- In the case of iSOC® installations where no electrical components are necessary for operation of the iSOC®, it is recommended that no electrical components be installed in the storage sheds, ground vaults or cabinets, which are considered enclosed areas. Enclosed areas shall be ventilated by openings located at a low point and at the highest point. A minimum of 10 volume exchanges of air per hour is recommended.

• For enclosed areas, an explosimeter or LEL detector shall be installed with a visible or audible alarm outside the area. This will warn the operator of a potential explosion prior to entering the area. Handheld or wall mounted hydrogen detectors can be found at http://www.h2scan.com/products.html.

• All cylinders are to be securely attached to a fixed structure.

• Do not store H_2 cylinders in the same room with oxygen cylinders.

• Ensure the pressure regulator is rated to the proper temperature range if the storage area is susceptible to freezing.

3. Tubing and Fittings

• Stainless steel tubing with compression fittings is to be used from the regulator to the wellhead. Paraflex CNG tubing with compression fittings can then be used for connections inside the well.

4. Well head space

• There is possibility of a rich Hydrogen environment in the head space of the well. Ventilation of the head space should be considered. As a minimum, the highest point of the well head should be open to atmosphere and warning labels to prohibit ignition sources within 20 ft (6 m) of the wells should be posted.

5. Warning Labels

• Placards in the official national language(s) should be posted at the entrance to any classified area or gas storage location to identify the presence of compressed gas, potential oxygen deficient atmosphere, presence of flammable gas products, and the need to ventilate the room adequately before entering due to risk of explosion.

• Warnings should also be posted to prohibit fire, ignitions sources and smoking near treatment wells.