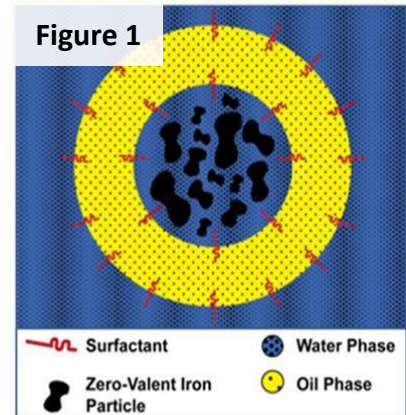


OVERVIEW

Emulsified zero valent iron (ZVI) combines food grade vegetable oil (VO) with a surfactant, elemental iron (ZVI) and water in a specific physical structure, to enable direct DNAPL, sorbed mass, and dissolved phase destruction utilizing a combination of abiotic and biotic processes. The key innovation surrounding the EZVI technology is the structure of the emulsion (Quinn *et al.*, 2005, Su *et al.*, 2017). For the NASA patented technology to perform as designed, the emulsion structure, which is a water-in-oil type emulsification, must be in place (see **Figure 1**). The structure of the EZVI technology enables:

- ◆ Miscibility with DNAPLs
- ◆ Continuous sequestration (phase partitioning) of contaminant into outer VO membrane (decreased mass flux)
- ◆ Encapsulates ZVI so that it targets only contaminants with hydrophobic physical chemistry



MATERIAL PACKAGING, HANDLING AND STORAGE

EZVI/EZVI-CH4® can be specially formulated to meet site-specific needs. The standard formulation contains 10% ZVI and is packaged as a liquid in IBC totes (275 USG or 330 USG) or 55 USG drums. Typical shipments entail forklift compatible IBC totes containing an average of 300 USG per tote or approx. 2,700 lbs of EZVI per tote. Each tote or drum is sealed to prevent exposure to precipitation, however, temperature exposure below 50° F will cause increased emulsion viscosity and temperatures near or below freezing (32° F) should be avoided.

GENERAL HEALTH AND SAFETY GUIDELINES

EZVI/EZVI-CH4 is non-hazardous and safe to handle. The use of standard personal protective equipment is always recommended, including safety glasses, steel-toe boots, gloves, hearing protection (in the proximity of loud machinery), and hard hats. Be aware that EZVI/EZVI-CH4 is hydrophobic and will stick to most surfaces, making them slippery. The SDS is posted on our web site on the EZVI technology page.

INJECTION PREPARATION

EZVI/EZVI-CH4 is shipped injection ready and does not require dilution. Experienced injection contractors can easily manage (mix/stir, transport/pump, and inject) the emulsion containing between 5% and 17% solids (defined as the amount of ZVI mass contained in the total mass of emulsion). Typical formulations of EZVI containing ca. 5 to 15% micro-scale ZVI will have the following general characteristics:

- ◆ Density = 1.05 to 1.10 g/cm³
- ◆ Viscosity = ca. 800 to 1,100 cP

APPLICATION TECHNIQUES

EZVI/EZVI-CH4 has been employed for source area treatment, plume treatment and/or plume management using permeable reactive barrier (PRBs). The choice of installation method will depend on the site-specific conditions, including treatment depth and geology. The most practiced *in situ* application method has been direct injection of the emulsion.

The EZVI/EZVI-CH4 emulsion containing 5 to 17% solids has been added to numerous aquifers using a variety of injection methods, including hydraulic fracturing, pneumatic fracturing, and direct injection. It can also be added via direct soil mixing using a range of equipment, or it can be placed directly into an open excavation or trench.

GENERAL GUIDELINES FOR DIRECT PUSH INJECTION OF THE EZVI PRODUCT

Mixing Equipment: Frequently the EZVI product is injected directly from the totes that it is shipped in. Typically, an inline pump (e.g., piston pump, pneumatic pump, screw pump) is used to stir (recirculate by drawing out of the bottom and pumping into the top) the tote, or homogenize the emulsion, prior to injection. The tote homogenization process usually takes about 15 minutes for each tote, and injections can proceed without interruption.

Pumps: Experienced drillers will have a variety of pumping equipment on site. For injecting EZVI, an injection pump capable of generating at least 300 psi of pressure at a flow rate of >5 gpm is desired. The pump should be able to handle solids, such as piston pumps, grout pumps, and progressing cavity pumps - with a preference towards the piston and grout pumps. EZVI is typically injected at pressures of 75 to 150 psi; however, higher pressures are sometimes required to initiate the injection. It is recommended to have a higher-pressure pump available on site that can generate over 500 psi and ca. >10 gpm, as deeper installations often require higher injection pressures.



Tooling. Experienced drillers will have sufficient rod length on site to allow 3 to 5 injection points to be capped overnight to allow pressure to dissipate. This can help prevent backflow and surfacing of emulsion as the injection rods are retracted. Likewise, experienced drillers will have on hand a variety of injection tips, including some that direct the slurry horizontally.



In a “top-down” injection approach, the rods are initially advanced to the top of the targeted depth interval, and a specified volume of emulsion is injected while recording flow rate, injection pressure, and emulsion volume delivered. The injection rods are then further advanced a distance ranging 2 to 4 feet and the process is repeated to help ensure even distribution of emulsion over the targeted depth interval. At the end of each injection point, a small volume of water (15 USG) is often used to clear the rods and the injection tip of any emulsion.



CONTACT US FOR A SITE EVALUATION

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