PRODUCT GUIDE

Mixing Guidelines for Dilution and Emulsification of ELS® Liquid Concentrate

ELS® Concentrate

INTRODUCTION

Evonik's ELS® is a field proven organic electron donor used to create reducing conditions to treat a wide variety of contaminants of concern. ELS® is typically injected as an emulsified liquid through fixed screen and direct push technology (DPT) injection locations. As an injectable liquid, ELS® can be distributed and used to create the desired reducing conditions throughout the treatment zone

ELS® Liquid Concentrate is Evonik's high purity version of ELS® that is easily emulsified in the field to reduce shipping volume and cost. ELS® is composed of cold-water emulsifiable complex food-grade carbon and nutrients which easily mixes with site water to achieve desired injection concentrations when following the directions within this guide. Indigenous or bioaugmented microbial organisms use ELS® to establish highly reducing conditions and generate molecular hydrogen required by dehalogenating organisms to convert toxic chlorinated organics to non-toxic compounds. ELS® is designed for easy on-site handling and distribution through the subsurface via existing wells, hydraulic injection networks, or direct push technology (DPT).

ELS® LIQUID CONCENTRATE PACKAGING

ELS® Liquid Concentrate is delivered in 55 USG drums. Each drum is filled 460 lbs or 209 Kgs. The drums will be shrink-wrapped and delivered four drums per wooden pallet. It is recommended that a pallet jack or forklift be available on site to move the drums.

ELS® INJECTION VOLUMES AND DILUTIONS

Depending on the application method, ELS® injection volume is typically between 10% and 100% of the total porosity. Injection volumes that are a higher percentage of the porosity aide in the distribution of the reagent in the subsurface. Depending on site conditions, this can be critical to the success of the application. Higher injection volumes are typically achieved using fixed wells and injection networks. This is in contrast to applications via direct push technology where injection volume can be limited to 10% to 20% of the total porosity. an ELS® direct injection concentration of 10 g/L to 50 g/L is typically targeted to achieve an in-situ concentration of 1 g/L to 5g/L in the total targeted pore space.

To facilitate the desired injection volume, the ELS® components are diluted in the field. Table 1 shows examples of mixing recipes for a 55-USG drum of ELS® liquid concentrate, in United States customary units (USC) and Table 2 in metric units.

TABLE 1 | ELS® DILUTIONS AND CORRRESPONDING CONCENTRATION, USC

TARGET INJECTION CONCENTRATIONS	10 g/L	30 g/L	50g/L
Volume ELS® Liquid Concentrate per Drum (USG)	55	55	55
Volume of water per needed per ELS® Liquid Concentrate drum (USG)	5445	1778	1045
Number of drums of water per drum ELS® Liquid Concentrate	99	32.3	19

TABLE 2 | ELS® DILUTIONS AND CORRRESPONDING CONCENTRATION, METRIC

TARGET INJECTION CONCENTRATIONS	10 g/L	30 g/L	50g/L
Volume ELS® Liquid Concentrate per Drum (L)	200	200	200
olume of water per needed per ELS® Liquid Concentrate drum (L)	19800	6467	3800
Number of drums of water per drum ELS® Liquid Concentrate	99	32.3	19

GENERAL ELS® EMULSIFICATION PROCEDURES

MIXING AND INJECTION WATER SOURCES AND CONDITIONING

ELS® Liquid Concentrate is an undiluted product that should be made into an emulsion and diluted to the target injection concentration on site prior to injection. Site groundwater (preferred) or another source such as potable water can be used to prepare the ELS® dilution.

Figure 1 | ELS® Liquid Concentrate

Dechlorinating bacteria such as Dhc are obligate anaerobes and are inhibited by the presence of oxygen. In addition, chlorine is a biocide and may negatively affect biological degradation processes and the viability of bioaugmentation cultures. If chlorinated, potable water, or water that otherwise contains oxidants that would negatively affect Dhc is used for injection water, it is recommended that the oxygen and chlorine be removed prior to mixing. Procedures for generating anaerobic injection water and removing chlorine can be provided upon request.

MIXING ELS® LIQUID CONCENTRATE

ELS® Liquid Concentrate has the appearance and approximate viscosity of honey (~3,700 centipoise (CP) at 20°C) (Figure 1). The concentrate can be quickly emulsified in the field using most emulsifier, centrifugal or shear pumps. An emulsifier pump with a Venturi induction system is shown in Figure 2. Typically, batches of ELS® emulsion at the target injection concentrations are prepared with volumes based on the injection schedule.

Figure 2 | In-line emulsifier pump with Venturi induction system

Prior to mixing, the holding tanks are filled with the predetermined volume of conditioned water. A recirculation line with an in-line emulsifier or centrifugal pump is installed to recirculate water out of and into the tank. A "T" or Venturi is installed in the line in front of the emulsifying pump. A predetermined volume of ELS® liquid concentrate is injected into this "T" as the water is recirculated.

A high viscosity transfer pump is usually used to meter the ELS® liquid concentrate from the drum to the recirculation line. Gravity flow and Venturi systems also have been used; however, an electric high-viscosity transfer pump is generally more reliable. Typically, an emulsifier, centrifugal or shear pump will emulsify the ELS® on the first pass through, however, additional mixing may be beneficial to assure a uniform mixing of the emulsion and any amendments.

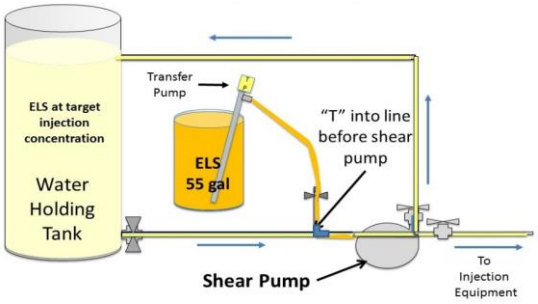

Figure 3 | Conceptual ELS® Mixing Set-up

Following the formation of the emulsion, soluble amendments such as pH buffers or a soluble iron amendment can be added to the injection solution. If the injection water is preconditioned to remove oxygen and chlorine bioaugmentation cultures may be added directly to the injection solution prior to the injection process. Alternately, bioaugmentation cultures may be added in slugs of anaerobic water in the injection line during the injection process.

PUMP RECOMMENDATIONS

A self-priming centrifugal pump is recommended for creating an injectable emulsion from the ELS® liquid concentrate. These pumps feature a self-cleaning clog resistant impeller capable of handling thicker liquids and semi-solids. A key element of the pump is a high RPM capable of generating sufficient shear to mix the ELS® liquid concentrate into an emulsion on the first pass through the pump head. A shear head specifically designed for creating an emulsion is shown in figure The AMT Model 2821-95 is a cast iron self-priming centrifugal pump with 1.5 HP, 1½ – 2" NPT port size, a max flow of 120 – 150 gallons per minute, and 3450 RPM which has been used successfully for this task.

A transfer pump, such as a high viscosity drum pump, is also recommended for moving the ELS® Liquid Concentrate from drums into the system where the ELS® can be emulsified. The Finnish Thompson (FTI) Model M58H is a continuous duty, variable speed motor, with 5,000 – 10,000 RPM, capable of handling a maximum viscosity of 20,000 CP, which has been used successfully for this task. In addition, air actuated pumps have been used as transfer pumps. Alternately to a transfer pump, the ELS liquid concentrate can be introduced into the system by gravity flow. A Venturi system can also be utilized to pull the ELS liquid concentrate into a recirculation line prior to the centrifugal pump. A picture of an emulsion pump with an in-line Venturi inductor system is shown in Figure 2. A shear head designed for efficiently creating an ELS emulsion is shown in Figure 5.

Figure 4 | ELS® Liquid Concentrate drum and transfer pump

Figure 5 | Shear head designed for efficiently creating an emulsion from ELS Concentrate.

The viscosity of ELS liquid concentrate increases substantially if the temperature of the substrate drops below approximately 10° Celsius. It is recommended that the materials be stored in a warm building. If that is not viable, external drum heaters may be used to maintain the temperature and viscosity in a range in which the ELS is easy to handle. Once the ELS emulsion has been established and diluted periodic mixing is recommended to maintain even distribution in the holding tank. A small submersible pump is usually satisfactory for this purpose. Because the emulsified ELS is highly bioavailable to microbes, fermentation of the substrate will begin in the holding tank, especially if site groundwater is used. This process will result in the generation of gasses such as carbon dioxide, methane and hydrogen. Therefore, venting of the tank is recommended.

HEALTH AND SAFETY

ELS® is safe when handled properly in accordance with instructions for use and the SDS, which is available upon request . When working with ELS, the use of standard personal protective equipment, including safety glasses, protective clothing and nitrile gloves are recommended. Additional safety equipment may be required for site operations. Always follow guidance provided in the SDS and local regulations.

Evonik Operations GmbH
Smart Materials
Active Oxygens Business Line
Soil & Groundwater Remediation

remediation@evonik.com
www.evonik.com/remediation

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