

Pumps and Equipment Cleaning

Subsurface application of PersulfOx® via pressure injection is commonly performed using either direct push technology (DPT) or wells. It ships as a **DOT 5.1 Class Oxidizer** and should be handled according to regulations governing oxidizers. In addition, when prepared onsite as an injectable solution, the equipment selected should be appropriate given the chemical nature of persulfate. Proper cleaning should be performed to minimize equipment degradation.

Typical Installation Equipment

- Direct push technology (DPT) rig with injection assembly or properly constructed injection wells
- Injection Pumps-see list/discussion below
- Injection hosing, manifolds, and a pressure relief valve with a bypass
- Suction resistant hose between mixing tank/drum and pump.
- Pressure gauges or transducers for existing wells
- Drum-type vortex/cyclone mixers attached to the tank, or;
- Power drill paint stirrer (3-inch diameter or smaller propeller tip), or;
- Trash pumps with a re-circulating hose configuration
- Plastic poly tanks and other semi-resistant materials to hold an alkaline solution or three to four 55-gallon poly drums or similarly sized mixing tanks for PersulfOx mixing
- Sand, bentonite chips, granular bentonite, cement, hydraulic cement, and quick-set concrete for closing and sealing temporary injection holes
- Access to water. (Note: cooler water temperatures [$<16^{\circ}\text{C}$ or 65°F] lower chemical solubility and/or solubility rate
- Access to electricity

Pump Information

REGENESIS has evaluated a number of pumps that are capable of delivering oxidants to the subsurface at a sufficient pressure and volumetric rate. Although a number of pumps may be capable of delivering the PersulfOx to the subsurface at adequate pressures and volume, each pump has a set of practical issues that must be considered to manage a specific field setting.

In general, REGENESIS recommends using a pump with a minimum pressure rating of 100 pounds per square inch (psi) in sandy formations or 800 psi in silt, clay or weathered bedrock formations, and a minimum delivery rate of 5 gallons per minute (gpm). We also strongly suggest checking the pressure ratings of every hose, fitting, and all other materials past the pump. Note that operating pressures (i.e., pressure required to deliver reagent to the formation) are typically substantially less than the pump capacity pressures. A variety of pumps may be used for oxidant injection including:

- 1) Double diaphragm (air-driven) pumps: Yamada-NDP-25E, Wilden- P-200 Advanced and T-2,
- 2) Positive displacement: Hydracell D-10 also, H-25 Hydracell
- 3) Gasoline-engine driven: Geoprobe Systems DP-800
- 4) Progressive cavity: Moyno 500 Series-333

Pumps features should include housing and internal parts that have reasonable chemical resistance for both caustic and corrosive fluids. We strongly suggest using poly, plastic and/or rubber type pump materials. Stainless steel will not hold up to PersulfOx use. Pumps with lower gpm ratings can be used; however, they are not recommended due to the amount of time required to inject the volume of liquids typically associated with a PersulfOx injection (i.e. 1,000 lbs of PersulfOx requires roughly 675 gallons of water to make a 15% solution). Prior to PersulfOx injection, a test injection using clear water is a useful procedure to determine the formation acceptance rate under a pressure-injection. For *in situ* oxidation projects, REGENESIS recommends testing volumes up to 15% greater than the design volume for a single-point injection.

Equipment Cleaning

It is important to clean all equipment during and especially at the end of each work day. Thorough flushing of pumps, tanks, and hoses with clean water is a necessary standard procedure for both health and safety of personnel as well as equipment care and longevity. PersulfOx is an alkaline product when in solution; if left to stand for a long period of time persulfate based products can become acidic and degrade equipment surfaces. For best results, use a hot water pressure washer (150 - 170 °F or 66 - 77 °C) to clean equipment and rods periodically throughout the day. Internal pump mechanisms and hoses can be cleaned by circulating hot water (and, as needed, mixed with a biodegradable cleaner such as Simple Green®) through the pump and delivery hose. Further cleaning and decontamination (if necessary due to subsurface conditions) should be performed according to the equipment supplier's standard procedures and local regulatory requirements. Assure that personnel involved in cleaning have the proper PPE and training to prevent exposure.