Hydraulic Fracturing for Injection

Hydraulic fracturing is used to improve the permeability of the subsurface. Hydraulic fracturing involves injecting a liquid or slurry solution at a pressure that exceeds the combined lithostatic pressure and cohesive strength of the formation. The lithostatic pressure is essentially equivalent to the weight of the soil column above the injection point. The cohesive strength is a measure of how well the soil particles are adhered to one another. For example, clays have significantly greater cohesive strength.

Redox Tech uses a Geoprobe® and a mobile injection trailer to complete hydraulic fracturing and to inject a wide variety of liquids and solids. The geoprobe rod is driven to depth, and then the outer casing is retracted to expose a proprietary injection nozzle. The fluid is pumped into the formation at a rate that exceeds the ability of the formation to accept the fluid. As a result, the pressure continues to rise until fractures are created. The injection pressure drops dramatically at the onset of fracturing (see Figure 1 below). Fracturing pressures for unconsolidated sediments at depths less than 50 feet can range from 80 psi to 250 psi. After fracturing occurs, fluid must be continuously injected to keep the fractures open. The injection pressure to keep the fractures open is called the maintenance pressure. The maintenance pressure is about 10% to 50% of the fracture pressure. The maintenance pressure will be relatively constant over the injection interval. However, if the injected material is a slurry, the maintenance pressure will increase gradually as the available pore space becomes filled with solids. If the maintenance pressure does not increase during the solids injection process, it can be an indicator that short circuiting is occurring. However, it can also indicate that there are large, high-permeability voids that are being filled. Inspection of geologic boring logs is crucial for properly designing a solids injection program.

Dense materials, such as zero valent iron (ZVI) require additional efforts to be successfully injected. ZVI has a relatively high specific gravity, and as a result, ZVI particles settle quickly from water solutions. Particle settling leads to clogged lines and poor distribution in the subsurface. To improve the buoyancy of the ZVI particles, guar gum is added to the slurry. The guar gum increases the density and viscosity of the solution, which in turn slows the settling rate of the ZVI particles. As the slurry is being injected, an enzyme is added that breaks down the guar – the guar is converted to sugars and water. The sugars promote anaerobic biodegradation of the chlorinated solvents. The anaerobic biodegradation works in concert with the ZVI to promote overall degradation of the plume. Eventually, the guar is completely consumed and the ZVI provides continuing chemical reduction of the target contaminant.

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Figure 1. Injection Pressure vs. Time