

# Hydrogen Release Compound (HRC-X®) Installation Instructions

## General Information

HRC-X® is a special formulation of the patented and widely accepted Hydrogen Release Compound (HRC®) which has been successfully installed on hundreds of project sites world-wide. It is specifically formulated to treat residual dense non-aqueous phase liquids (DNAPL) in the groundwater and provide a long-term solution to groundwater plume control. HRC-X is manufactured as a viscous gel that can be injected into the saturated zone in a grid- or barrier-based configuration for either localized area or cutoff- based treatment approaches.

The use of HRC-X for groundwater remediation offers a comparatively simple and cost effective remediation alternative for sites that would otherwise require unacceptably long periods of time for natural attenuation or the high levels of capital investment and operating expense associated with active remediation technologies.

REGENESIS® believes that the best method to install HRC-X into the subsurface is using direct-push drilling techniques. This method allows for the product to be pushed into the formation instantly and provides greater coverage/treatment over the life of the product. As a minimum the following equipment will be needed to perform this type of installation:

- Direct-push drilling unit
- Grout pump
- Appropriate hose assembly including a fitting that links a hose from the grout pump to the direct-push rods
- A method to heat the HRC-X (see below)
- 100+ gallon Water tank (or equivalent)
- Pressure washer (or equivalent) for cleaning

## When is HRC-X Appropriate?

HRC-X should not be considered appropriate for all potential HRC projects because of its physical and chemical characteristics. The viscosity of the product is approximately 10x greater than that of HRC and its release period is about twice as long. Based on their cumulative project experience REGENESIS' Technical Service Group (TSG) has determined that there are specific conditions that justify the use of HRC-X for a specific project.

## The Conditions Are:

- The total concentration of tetrachloroethene (PCE) and trichloroethene (TCE) exceeds 100 mg/L
- The groundwater velocity at the site is greater than one-foot per day
- The application location is currently not accessible or will not be in the future and re-application(s) of the product are not feasible

## Material Overview, Handling, and Safety

At this time, HRC-X is sold and distributed in plastic buckets only. Each bucket has a volume of 4.25-gallons and has a gross weight of approximately 32-pounds (net weight of HRC-X = 30-pounds). At an ambient temperature of approximately 70 °F (21 °C) the viscosity of HRC-X is approximately 200,000 centipoise which is similar in consistency to very cold honey. However the viscosity of HRC-X is temperature sensitive and REGENESIS' TSG has observed significant changes in the viscosity of the material after it is heated to temperatures greater than 110 °F (43 °C).

HRC-X should be stored in a place that is dry and warm and should not be left directly in the sunlight. After HRC-X has been stored for an extended period of time it is not uncommon for a thin layer of material to form at the bottom of the bucket. Therefore, the material should be mixed into a uniform fluid before installation.

During installation activities REGENESIS recommends that field personnel use at least level D personal protection equipment (PPE). It is highly recommended that eye protection and gloves be used throughout the installation process because of the product's low pH and high viscosity. In addition, even though the product is made using only food grade raw materials, REGENESIS does not recommend its consumption. A Materials Safety Data Sheet (MSDS) is sent with each shipment and should be reviewed before proceeding with installation activities.

## Specific Installation Procedures

1. Prior to the installation of HRC-X, all surface and overhead impediments should be identified as well as the location(s) of any underground structures. Underground structures include but are not limited to: utility lines (gas, electrical, sewer, etc), drain piping, and landscape irrigation systems.
2. The planned injection locations should be adjusted in the field to account for impediments and obstacles.
3. The actual injection locations should be marked prior to the start of installation activities to facilitate the application process.
4. To expedite the installation process, REGENESIS strongly recommends heating the HRC-X material in a hot water bath prior to application. Once the HRC-X reaches a temperature of approximately 110 °F (43 °C) it becomes less viscous and can be pumped much more easily. This is accomplished by adding hot water, 160 °F+ (71 °C), to a large trough (plastic or metal) and then placing the buckets of HRC-X product inside. REGENESIS has used the following methods to heat up water:
  - Heated pressure washer
  - Steam cleaner
  - Camping stoves
  - Propane tanks

\*Please note that the buckets used to package the HRC-X product should not be heated directly, another medium such as water must be used so that the physical structure of the buckets is not jeopardized.

5. The period of time needed to heat the HRC-X product up to the desired temperature of 110 °F (43 °C) is highly dependent on ambient conditions (i.e. cold weather conditions will require more

- time) and can take up to 1.5 hours.
6. After the HRC-X product reaches the target temperature the installation activities can begin
  7. Using an appropriate pump to install the HRC-X™ product is very critical to the success of the application as well as the overall success of the project. Based on our experience in the field, REGENESIS strongly recommends using a pump that has a pressure rating of at least 1,500 pounds per square inch (psi) and a delivery rate of three gallons per minute.
  8. After the HRC-X product has been heated the direct-push unit can be moved over one of the targeted injection points and prepared for installation. The drive rod assembly should be fitted with a disposable tip on the first drive rod and pushed down to the desired depth. This process should be done in accordance with the manufacturer's standard operating procedure (SOP). Due to the viscous nature of the product, REGENESIS recommends using drive rods with an inner- diameter of at least 0.625-inches.
  9. The quantity of HRC-X product needed for each injection point should be poured into the pump's hopper after it has been heated to the appropriate temperature and before the drive rods are pushed down to the desired depth.
  10. A sub-assembly connecting the delivery hose to the drive rods and pump should be used. The sub-assembly should be constructed in a manner that allows for the drive rods to be withdrawn while the material is being pumped.
  11. Prior to connecting the hose to the sub-assembly a volume check should be completed to determine the volume and weight of product displaced with each pump stroke (see Table 1).

**Table 1 – Volume Check Information**

Volume of HRC- X Pumped	Number of Pump Strokes Required	Density of HRC- X	Mass of HRC-X per Pump Stroke
3.0 gal	14	10.8 lbs/gal	2.3 lbs
3.0 gal	10	10.8 lbs/gal	3.2 lbs

12. After the drive rods have been pushed to the correct depth the assembly should be withdrawn three-to six-inches so that the disposable tip has room to be dropped.
13. Fill the annular space of the drive rods with water. This will minimize the amount of air introduced to the system.
14. Connect the hose from the grout pump to the drive rod assembly
15. Start pumping the HRC-X product
16. The initial volume of HRC-X pumped should only be enough to displace the water within the drive rods. Once this is done the actual injection can start.
17. Begin withdrawing the drive rods, in accordance with the manufacturer's SOP, and start pumping the HRC-X simultaneously. The withdrawal rate should be such that it allows the appropriate quantity of material to be injected into each vertical foot of aquifer being treated. The withdrawal rate should be slow. If the drive rods are withdrawn too quickly a vacuum can be created and pull the product to the surface.
18. Depending on site-specific conditions, a different approach may need to be used. Less permeable soils such as clays and silts may have difficulty accepting the volume of material being installed. In this case REGENESIS recommends using a "step-wise" application approach. For this approach we suggest withdrawing the drive rods in one-foot increments and then injecting the quantity of material required per foot.
19. Look for any indications of aquifer refusal such as:
  - Excessive pump noise such as squealing
  - Surfacing of material through the injection point (typically called "blow-by")

If acceptance appears to be an issue it is critical that the aquifer is given enough time to equilibrate

before breaking down the drive rods and/or removing the hose. The failure to do this can lead to excessive splashing of the product on personnel, equipment, and the ground surface.

20. If HRC-X continues to “surface” after the drive rods have been completely removed from the borehole a plug may need to be used. Large diameter disposable tips or wood stakes have been used successfully for this purpose.
21. Drive rods should be disconnected after one rod (typically four-feet) has been withdrawn. The drive rods should be placed in a bucket (or equivalent) after they have been disconnected. More often than not some residual HRC-X will remain in the drive rods and the bucket can be used to collect this residual material. The collected material should be poured back into the pump hopper periodically.
22. Install HRC-X at the designated application rate across the entire targeted vertical interval.
23. After the injection is complete, an appropriate seal should be installed above the vertical interval where the HRC-X has been placed to prevent contaminant migration. Typically bentonite powder or chips are used to create this seal. However, consultants should review local regulations before beginning field installation activities to confirm that this approach can be used.
24. Complete the borehole at the surface as appropriate using concrete or asphalt.
25. Repeat steps 12-24 until the entire application has been completed.

## **Helpful Hints**

### **A. Applications in Cold Weather Settings**

The viscosity of HRC-X is directly related to ambient temperature conditions. To maintain the temperature of HRC-X you can:

- Keep temperature of the product at or above 110 °F (43 °C) before pouring it into pump hopper
- Insulate the hose(s) used to deliver the material from the pump to the drive rods
- Place the pump and hot water bath used to heat the product inside a building or equivalent structure (e.g. cargo van)
- Periodically check the temperature of the product in the pump hopper
- Occasionally re-circulate the product through the pump and hose to maintain temperature and viscosity
- The volume of product re-circulated should not exceed the quantity of material in the pump hopper
- Do not constantly recirculate the product through the pump and hose(s). It could potentially affect the longevity of the product

### **B. HRC-X Physical Characteristics**

- Density: 1.3 g/cc or 10.8 lbs/gal
- Viscosity: 200,000 centipoise

### **C. Grout Pump Cleaning**

The physical characteristics of the product make it a challenge to work with during installation and an even bigger challenge to clean after the installation has been completed. The internal workings of the grout pump can be cleaned easily by recirculating a solution of hot water and a biodegradable cleaner through the pump and delivery hose(s). If additional cleaning and decontamination is required it should be conducted in accordance with the manufacturer's SOP and local regulatory requirements.

**For more information contact REGENESIS at 949.366.8000**