



**HYDROGEN
RELEASE
COMPOUND**

Application Instructions



HRC, HRC Primer, HRC-X Quick Reference Table

The following table is a quick reference guidance providing only the most relevant information. Please review the entire document carefully, plus the product Safety Data Sheet prior to any application. Please contact REGENESIS Technical Support if you need any further assistance.

Existing formulations	HRC Primer (2000 cP viscosity; several weeks release) HRC (20,000 cP viscosity; 18-24 months release) HRC-X (200,000 cP viscosity; 5 years release)
Viable application methods	Direct push In wells
Typical dilution factor	To be applied pure (no dilution with water) Dilution with an equivalent amount of water interferes with longevity of release Small amounts of water (e.g. 1 or 2L) possible for containers cleaning and equipment flushing
Mixing activities	For HRC and HRC-X: heat the product in sealed containers to 35-40 °C Homogenize concentrated product before transferring Transfer concentrated product to application hopper
Mixing activities – co-application with other amendments	In case of co-application with other high volume amendments, apply separately, and apply HRC after other amendments. Only HRC Primer can be co-mixed with 3-D Microemulsion and co-applied (mix 3DME with water first, and then add HRC Primer). Refer to 3DME application instructions for information
Recommended injection pump	Positive displacement pump (progressive cavity or piston pump)
Recommended injection pressure	Low to average pressure injection. Typically 2-8 bar Adjust pressure using pressure regulator Take note of pressure and flow rate for each step
Direct push injection	Use a pressure activated tip or a retractable screen tip Typical injection steps every 30 cm More info on direct push injections
In well application	Pressure injection; <u>DO NOT</u> gravity feed Use double packer (single packer only for wells with short screened interval) Flush well with small amounts of clean warm water after application More info on injection well applications
Other recommendations	Always wash and flush equipment with small amounts of warm clean water Seal injection direct push points after injection Do not operate P&T or other activities likely to disturb groundwater in surrounding area during and after injection
Recommended monitoring	Typically, monthly to quarterly monitoring. Monitoring period typically 9 months to 2/3 years Parameters: contaminants of concern. Supporting evidence: O ₂ , redox, pH, electrical conductivity, Fe, Mn, nitrates, sulphates, eventual daughter products (Fe & Mn need to be filtered and acidified in the field)

Application Instructions

Hydrogen Release Compound (HRC[®]), Hydrogen Release Compound Primer (HRC Primer[®]), and Hydrogen Release Compound Extended (HRC-X[®]) are a family of REGENESIS technologies designed for the anaerobic in situ bioremediation of chlorinated compounds. Their main characteristics are summarised in Table 1 below.

Product	Main Constituents	Hydrogen Release Period	Approximate Viscosity (cP)
HRC Primer	Lactic acid	Several weeks	2,000
HRC	Poly lactate esters, Glycerol	18-24 months	20,000
HRC-X	Poly lactate esters	5 years	200,000

Safety Data Sheets will be supplied with all delivered products. These should be read carefully prior to product handling. It is assumed that the user is appropriately trained and competent and will have completed a comprehensive site-specific health, safety & environmental risk assessment for the works they intend to carry out.

Pre-Application Guidance

HRC products are shipped in **18.1kg** or **13.6kg buckets**. The buckets are generally delivered to site on pallets via a heavy goods vehicle. Please discuss any site access restrictions with REGENESIS, so an appropriately sized delivery vehicle is used.

As shown in Table 1 above, the viscosity of the HRC products varies greatly. While HRC Primer can be poured relatively easy directly from the bucket, HRC-X (and to a lesser extent HRC) are too thick to pour at ambient outside temperatures in most regions and require heating.

The most convenient method of heating HRC products is to place them in a warm water bath with a variable temperature setting. The unopened buckets should be placed in the bath, then water added to just below the top of the bucket. The water temperature should be set to between 50 °C and 60 °C with an aim to heat the HRC products to an approximate temperature of 35 °C. Please note this may take several hours.

Water will need to be added as buckets are removed to maintain sufficient volume in the tank. Some residue will be left in the bucket after adding product to the mixing tank. This can be removed by adding a small amount of warm water and agitating using a battery powered drill with a mixing attachment or a hand-held paddle/scraper.



Fig 1. HRC tubs in heating bath



Fig 2. Individual heaters in HRC buckets

Injection Equipment

Due to the high viscosity of HRC products, standard injection equipment used to inject high volume products is generally not suitable. An exception to this rule is when HRC Primer is added to a high-volume product such as 3DME. However, if applicable this will be specified by REGENESIS during the design phase of the remediation strategy.

A limited number of pumps are capable of transferring high viscosity products such as HRC and HRC-X. REGENESIS recommends that a positive displacement pump, such as progressive cavity or piston pump is used for injection of HRC products; a diaphragm pump will generally not be suitable for application of HRC and HRC-X. The pump should have a graduated hopper (ideally, situated directly above the pump intake) to which the products can be added, allowing the product to move directly into the pump chamber via gravity. Graduations within the hopper give an indication of the volume of product applied.

Where the injection design specifies a mix of HRC products, these should be mixed together in the specified proportions (usually specified by REGENESIS during the design phase of the remediation strategy) in the pump hopper, so that an even dose is applied to the target injection location.

A small quantity (1-2L) of warm water per bucket of HRC product can be added to the hopper to thin the mixture slightly if necessary. The water used to remove residue from the bucket can be used for this purpose. The mixture should be recirculated in the hopper for a few minutes prior to injection to thoroughly mix the product. **Please note that adding greater quantities of water to the HRC may reduce product longevity in the subsurface.**

Direct Push Application

The most suitable application method to deliver HRC products into the subsurface is via Direct Push injection, as this allows the most uniform distribution throughout the aquifer. REGENESIS recommends using a 300mm or 600mm retractable injection tip for application of HRC products, as this provides good distribution of low volume products.

Once the requisite volume of HRC product has been applied to the injection location, warm water (from the heating bath) should be used to flush the pump and injection equipment. Flushing with significant amounts of water should not be carried out in between injection intervals as this could lead to dilution of the HRC products.

Injection Well Application

Where possible, direct push should be used for application of HRC products. However, where application method is limited by the geology or target depth for example, injection wells can be used.

REGENESIS recommends using a double packer to isolate a discrete injection depth when injecting HRC products via injection wells, ensuring adequate distribution across the target zone. Use of a double packer should be considered during well design prior to well installation. REGENESIS can provide guidance on well design as required.

If multiple products are to be applied into the same well, HRC products should be injected **after** other high-volume products.

Once the requisite volume of HRC product has been applied to the injection location, warm water should be used to flush the pump and injection equipment. Warm water flushing should not be carried out in between injection intervals as this could lead to dilution of the HRC products.