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# Application Instructions





## CRS® 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.

<b>Viable application methods</b>	Direct push In wells
<b>Typical dilution factor</b>	CRS is co-applied with 3-D Microemulsion (3DME) Apply pure CRS to the 3DME already mixed with water Dilution factor for 3DME: 1:6 (exact dilution to be discussed with REGENESIS) 1 kg of 3DME concentrate in 6 litres of water
<b>Mixing activities</b>	Homogenize concentrated 3DME before transferring Transfer concentrated product to tank already filled with water Mix and homogenize 3DME with water Homogenize concentrated CRS before transferring Transfer concentrated CRS to 3DME+water tank Mix and homogenize
<b>Recommended injection pump</b>	Diaphragm pump
<b>Recommended Injection pressure</b>	Low pressure injection. Typically 1-5 bar Adjust pressure using pressure regulator Take note of pressure and flow rate for each step
<b>Direct push injection</b>	Retractable screen tip recommended; pressure activated tip as an alternative Typical injection steps every 30 cm
<b>In well application</b>	Low pressure injection; <b>DO NOT</b> gravity feed Use single or double packer Flush well with clean water after application
<b>Other recommendations</b>	Minimize contact of CRS with air Always wash and flush equipment with 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
<b>Recommended monitoring</b>	Typically, monthly to quarterly monitoring. Monitoring period typically 9 months to 2/3 years Parameters: contaminants of concern. Supporting evidence: O <sub>2</sub> , redox, pH, electrical conductivity, Fe, Mn, nitrates, sulphates, eventual daughter products (Fe & Mn need to be filtered and acidified in the field)



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## Chemical Reducing Solution (CRS)

Chemical Reducing Solution (CRS<sup>®</sup>) is a liquid amendment to 3D Microemulsion<sup>®</sup> (3DME) that provides ferrous iron (Fe<sup>2+</sup>) to the reductive dechlorination process, thus enabling In-situ Chemical Reduction (ISCR) pathways for contaminant destruction. The material is added in a prescribed ratio to the 3DME mixture before injection.

CRS Safety Data Sheets will be supplied with all delivered products. These should be read carefully prior to CRS 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

CRS is typically supplied in **181.4kg drums**, which are shipped 4 drums to a pallet on a heavy goods vehicle. Please discuss any site access restrictions with REGENESIS, so an appropriately sized delivery vehicle is used.

Prior to CRS and 3DME application, REGENESIS recommends completing a pre-application test injection using clean water. This procedure is useful to determine the quantity of liquid the target zone will accept and will provide valuable flow rate and pressure information to inform the subsequent product injection. REGENESIS recommends the injection test volume of water is in the range of **15-20% greater** than the single-point design volume e.g. if the design specifies a combined product volume of 1,000L per point then the water test injection should aim for 1,150L – 1,200L.

## Mixing Instructions

CRS contains reduced ferrous iron (Fe<sup>2+</sup>) and will oxidize slowly to ferric iron (Fe<sup>3+</sup>) in air. To maximize the reducing capacity of the solution, exposure to air should be minimized prior to injection of the material. Therefore, it is important that the drums CRS is delivered in stay closed and air-tight until CRS is ready to be added to 3D Microemulsion.

As previously stated, CRS is designed to be used as an amendment with 3DME. 3DME should only be applied after dilution with water - as a high volume, microemulsion. In this form it offers optimal distribution of the 3DME material throughout the target aquifer from the injection point. This in turn will



result in minimal number of injection points required overall for the project, reducing time and cost. The production of a 3DME injection-ready microemulsion generally involves the on-site, volumetric mixing of 6-parts water with 1-part 3DME concentrate to form the injection-ready 3DME microemulsion. For example, 700L of injection-ready microemulsion would require 600L of water and 100kg of 3DME concentrate.

The CRS should be mixed in an appropriately sized tank, preferably conical or flat bottomed to aid mixing. Mixing can be achieved using a high flow pump via recirculation or mechanically using a paddle mixer. REGENESIS recommends that mixing proceed in the following order:

1. Obtain dosing for emulsion preparation and CRS addition from REGENESIS
2. Dilute 3D Microemulsion with the prescribed quantity of water
3. Stir drum of CRS for 30 seconds with a paddle mixer at a mild turbulence setting to ensure solution homogeneity without air entrainment
4. Transfer the prescribed quantity of CRS into the 3D Microemulsion batch
5. Mix the emulsion and CRS batch using a paddle mixer – note: care should be taken to:
  - i. Minimize direct exposure and entrainment of air
  - ii. Mix periodically to maintain homogeneity of batch
6. Inject the final mixture directly into the treatment zone

Depending on the level of the mixing tank, mixed product in the mixing tank may siphon back into the containers of concentrated product. This can be avoided by installing lever valves on the supply hose or removing the supply hose from the mixing tank after adding 3DME or CRS.

## Direct Push Application

A typical CRS project will only require a single application. As multiple applications are not necessary, and where geological conditions are suitable, direct-push application is the preferred application method (lower costs as compared to injection well installation). The injection rods should be advanced to the target depth and the CRS injection-ready solution applied, while note is taken of the flow rate and pressure. Once the requisite volume has been applied evenly over the target horizon, clean water should be used to flush through the pump, hoses and injection tip to ensure all product has been displaced into the formation. Once the point has been completed the injection hole should be sealed with bentonite



or cement. The purpose of this effort is to seal off any potential pathways to the surface and in doing so reduce the risk of product flowing upwards ('day lighting').

If the product application is based on a grid design, the application should ideally be performed by systematically working from the outside to the centre of the injection array to minimise local mounding of groundwater. Where possible, a suitable distance should be maintained between consecutive injection locations to avoid localised overloading of the formation with injected product (e.g. inject at every 3<sup>rd</sup> point in a barrier).

## Well Application

CRS and 3DME can be injected via fixed injection wells where direct push is not considered practical. REGENESIS recommends that injection wells should generally be constructed using **≥50mm diameter HDPE**. Where possible, the well seal above the slotted section should consist of a maximum of 300mm of bentonite pellets, above which a sand & cement mix should be applied to seal to the surface. Prior to injection of any remedial reagent, REGENESIS recommends that the injection wells be purged of fine-grained particles present in the well bore to the extent practicable.

When wells are used for CRS and 3DME injection, the injection wells and nearby groundwater monitoring wells should be either tightly capped or alternatively equipped with a pressure gauge and relief valve. This will reduce potential for daylighting.

Once the requisite volume has been applied evenly over the target horizon, clean water should be used to flush through the pump, hoses and well to ensure all product has been displaced into the target formation.

REGENESIS would advise that all equipment is flushed through with clean water at the end of each working day and on completion of the injection works.