

## Advantages of BerdeSol™

**Purpose** This document summarizes the enhanced environmental, safety and performance attributes of TBF Environmental's "zero VOC" heptane replacement. BerdeSol is designed as a replacement for Heptanes and other organic solvents that are used for cleaning/degreasing purposes, and are used as a primary or co-solvent in a variety of applications.

**Factors to consider** When comparing the safety and quality of BerdeSol to traditional organic solvents, the following factors should be considered:

- Environmental considerations - toxicity and regulatory controls
- Safety - reduced hazard to the environment and workers
- Performance - comparable physicochemical characteristics to Heptanes and other solvents that may be replaced with BerdeSol

**Environmental considerations** The following table compares the environmental considerations of BerdeSol to Heptanes:

	BerdeSol	Heptanes
<b>VOC Content: US EPA</b> (outside SCAQMD)	<b>0</b>	100%
<b>VOC Content: SCAQMD</b>	<b>0.9* g/L</b>	100%
<b>Maximum Incremental Reactivity</b> (MIR, g O <sub>3</sub> / g organics)	<b>0.047</b>	1.28

\*ASTM Test Method 313-91. South Coast Air Quality Management District (SCAQMD) considers <5 g/L VOC content to be "zero VOC". BerdeSol is comprised solely of solvents considered to be VOC-exempt by the EPA, CEPA, NPRI and SCAQMD, and as such is considered "zero VOC".

BerdeSol is far less toxic to the environment than commonly used conventional organic solvents. Heptanes are emitters of Volatile Organic Compounds (VOCs), which can engage in photochemical reactions in the atmosphere to form ground-level ozone and smog precursors which are harmful to the environment. By contrast, BerdeSol is formulated solely with VOC-exempt materials.

MIR is a quantifiable measure of the relative ground-level ozone impacts of VOCs. A lower MIR value indicates less impact on the environment and health. BerdeSol has a very low Maximum Incremental Reactivity (MIR) value compared to Heptanes.

**Safety** The following table details the safety considerations of BerdeSol and Heptanes:

	BerdeSol	Heptanes
<b>Flash Point ( °C)</b>	<b>5.4</b>	-4
<b>Oral LD<sub>50</sub> (rat) (mg/kg)</b>	<b>5000 -13,000</b>	> 5000

The flash point of BerdeSol is higher than that of Heptanes which indicates a less flammable and consequently safer solvent for transport, handling and use.

LD<sub>50</sub> values can be used to determine the toxicity of a chemical. LD<sub>50</sub> is the quantity of a material, given all at once, which causes the death of 50% (one half) of a group test population. The LD<sub>50</sub> is one way to measure the short-term poisoning potential (acute toxicity) of a chemical product, and a larger LD<sub>50</sub> value correlates to a product that has less acute toxicity. The oral LD<sub>50</sub> (rat) for the components in BerdeSol range from 5000 to 13,000 mg/kg, which provides a range that is higher than the oral LD<sub>50</sub> (rat) value for Heptanes.

**Physical properties**

In addition to environmental and safety considerations, in order to be useful as a replacement solvent, the performance characteristics of BerdeSol should be similar or superior to that of Heptanes. The following table summarizes various physical properties of BerdeSol and Heptanes.

	BerdeSol	Heptanes
<b>Evaporation Rate</b> (n-Butyl Acetate = 1)	<b>2.5</b>	3
<b>Surface Tension</b> (dynes/cm)	<b>20.4</b>	20.1
<b>Kauri Butanol (Kb) Value</b>	<b>51.3</b>	29
<b>Hansen Solubility Parameters</b> (MPa) <sup>1/2</sup>	<b>14.9</b>	15.3
<b>Dispersion (<math>\delta_D</math>)</b>	<b>13.8</b>	15.3
<b>Polarity (<math>\delta_P</math>)</b>	<b>4.5</b>	0
<b>Hydrogen Bonding (<math>\delta_H</math>)</b>	<b>3.6</b>	0

BerdeSol has a comparable similar evaporation rate and surface tension to Heptanes. The dispersion properties of BerdeSol are also similar to the dispersion solubility parameters for Heptanes.

The solvency, expressed as Kauri Butanol value, for BerdeSol is 51.3, while Heptanes has a value of 29. This demonstrates that BerdeSol has greater solvency compared to Heptanes and can thus perform more efficiently as a solvent.

**Conclusion**

As described above, BerdeSol is a zero-VOC solvent alternative to the Heptanes and other solvents that exhibits lower toxicity than many conventional solvent alternatives with a safer and superior environmental and performance profile. It is useful as a brake cleaner/degreaser, cleaner, and as a primary and co-solvent in formulation and in a wide variety of applications.

**References**

- Carter, William P.L. [Updated Maximum Incremental Reactivity Scale and Hydrocarbon Bin Reactivities for Regulatory Applications;](http://www.engr.ucr.edu/~carter/SAPRC/MIR10.pdf) <http://www.engr.ucr.edu/~carter/SAPRC/MIR10.pdf> Updated January 28<sup>th</sup>, 2010. (Accessed July 16<sup>th</sup>, 2015).
- Chevron Phillips Chemical Company LP SDS for Heptanes: [http://www.cpchem.com/msds/100000067062\\_SDS\\_US\\_EN.PDF](http://www.cpchem.com/msds/100000067062_SDS_US_EN.PDF) (Accessed October 15th, 2015)