FE-1
Flow-Back Enhancer

Applications:

FE-1 is a biodegradable, thermodynamically stable, microemulsion, (clear mixture of solvent, co-solvent and surfactant) designed specifically for use as a stimulation additive. FE-1 offers superior performance in enhancing the penetration and cleanup of water based frac fluids. FE-1 is a proprietary blend of natural surfactants (nonionic) formulated above CMC (critical micelle concentration). CMC is the concentration of surfactant in solution above which the development of micelles creates an instant contact effect by lowering the surface tension. The proprietary natural solvent (non-aromatic) is blended at an optimum ratio with the surfactant to produce stable microemulsions when mixed with the desired aqueous phase component. FE-1 is effective when present in: 1) hydrocarbon in aqueous phase; 2) aqueous phase in hydrocarbon phase or 3) equilibrium aqueous and hydrocarbon phase. Surface tensions to 25-28 dynes /cm^2 are typical.

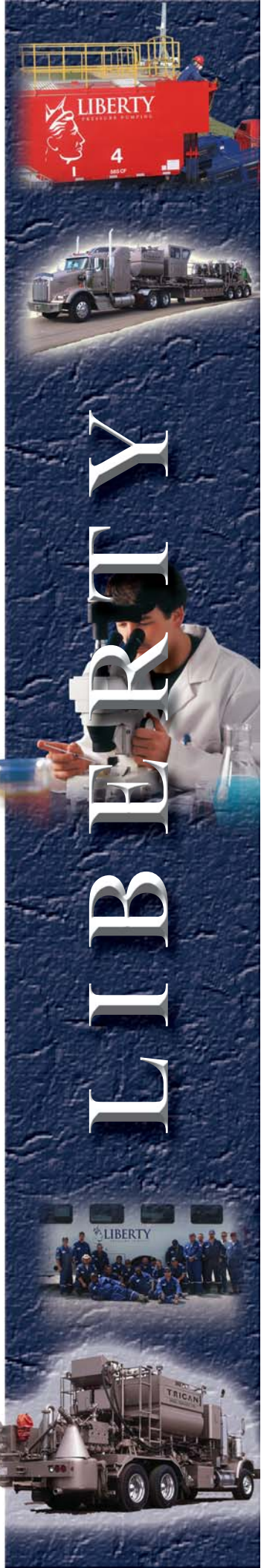
FE-1 is normally run between 0.1% and 2.0%.

Properties:

Appearance	Clear viscous liquid with pleasant odor
Solubility	Soluble in water and hydrochloric acid
Flash Point	77 ºF
Specific Gravity	0.94
Freezing Point	< -40 ºF

Advantages:

- Dispersible and non-reactive with common fracturing and acidizing additives.
- Exhibits demulsification properties with some crude oils and condensates, although each should be checked for compatibility. Compatible with Liberty's water based frac fluids including borate, zirconium, N_2 foam and ECO_2 frac fluids. Also compatible with Liberty's oil-based frac gels.
- Has shown excellent clean-up characteristics in hydraulically fractured sandstones and CBM (coalbed methane) wells.



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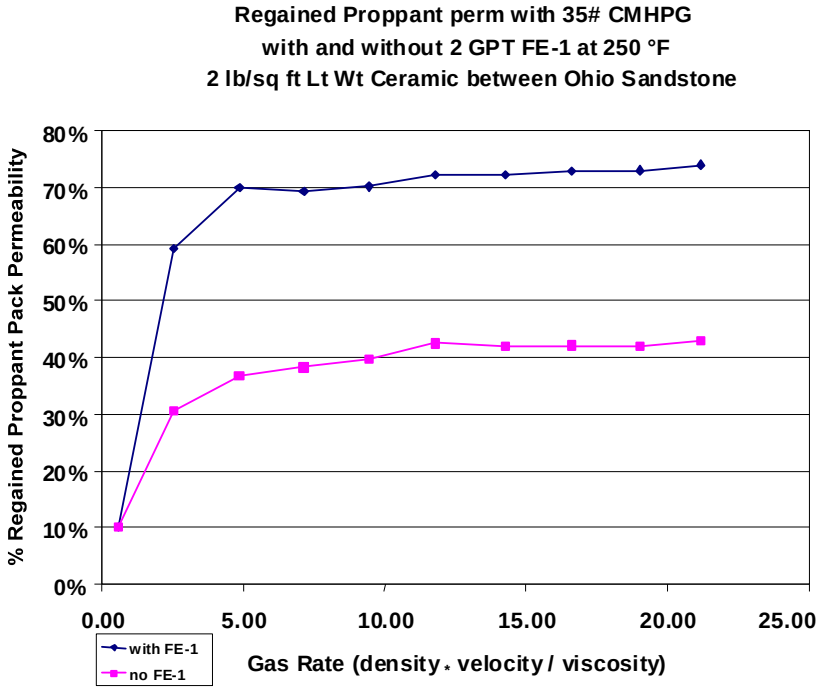
Limitations:

- Upper temperature limit of 285 °F in acid.
- Has a slight negative effect on foam stability.

Handling Precautions:

- Flammable liquid and vapor.
- Direct skin or eye contact may cause irritation; flush with water as soon as possible.

Product Data:



A series of tests were conducted at Stim-Lab comparing a 35lb CMHPG + Zr at 250 °F with and without 2.0 GPT FE-1. Neither test has breaker present. The tests are run by statically leaking off the gel while closing on a 2 lb/sq ft pack of 20/40 Light Weight Ceramic Proppant. 3% KCL is flowed back through the core and proppant pack to simulate flowing back the well for 6 hours. Gas is then flowed at simulated rates of 100 MCFD to 1 MMCFD. The plot shows units of the gas density *velocity / viscosity. The test without FE-1 cleans up to 43% while the test with 2.0 GPT FE-1 cleans up to 74%. Another

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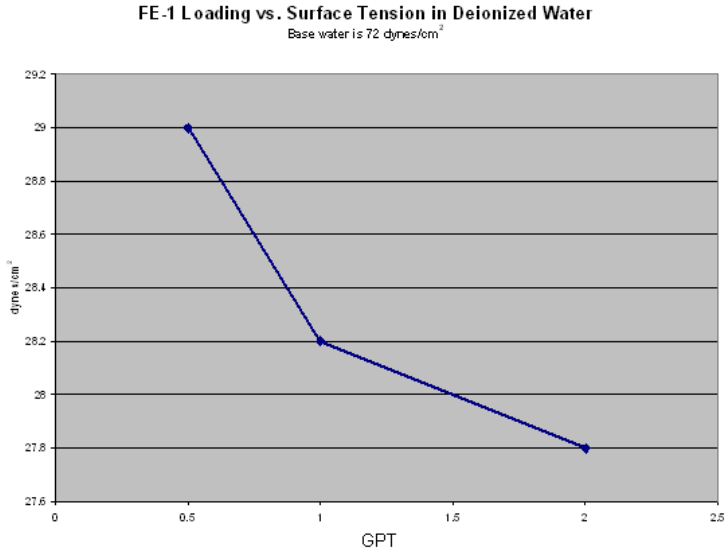
Product Data (cont'd):

observation is that the cleanup to near 60% is possible with very low gas rates where normally the cleanup is 30% or less.

The ability of the FE-1 to lower surface tension while retaining its microemulsion characteristics is new to the industry. The unique micro-polyhedral structures once added to the treatment carrier fluid travels to the reservoir as a micro-dispersion, and then spreads their interfacial tension lowering effects and contact angle reducing effects on whatever substrate they would come in contact with throughout the volume of reservoir contacted. The FE-1 is a finished microemulsion additive that is structured so that it's components would not dilute when placed in water, acid, and or oil.



Mixing & Blending Instructions:

- FE-1 should be added directly to the mix water.
- Antifoaming agent may be used if excessive foaming is observed.

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