

Nitrogen As a Fracturing Fluid



Superior's N₂ service supports foam-frac procedures and gas fracs in shale.

N₂ Capabilities

Superior Well Services Inc. (SWSI) uses mobile (3,000-gal liquid N₂ capacity) nitrogen pumping units to pump gaseous nitrogen at pressures up to 8,500 psi and at rates from 60,000 scf/hour to more than 600,000 scf/hour.

SWSI pumpers are designed to include the essential insulation and tank design features to prevent evaporation of nitrogen, which is cooled at -320° F for transport and pumping. N₂ is converted from liquid form to gas to support foam fracs and gas fracs. Electronic controls and advanced hydraulics enable efficient use of the modern, fired-nitrogen pumps. The truck engine powers the high-pressure pump, and an auxiliary diesel engine powers the direct-fired vaporizer. Superior's pumping fleet comprises 46 of these units.



Nitrogen Pumping Unit.

Foam Fracs

The SWSI pumping fleet generates up to 75-quality foam to act as a carrier fluid to transport proppant into fractures. The foam is compatible with all standard mesh sizes and proppant types (including resin-coated proppants), and supports jobs pumping the highest proppant volumes. Friction reducers and/or gels can be added to the fluid mix as necessary. SWSI foams the frac fluid at the wellhead to reduce erosion of tubular goods and surface equipment.



Wellhead setup used for foam fracs and gas fracs.

Use of nitrogen-foamed fluids yields these operational benefits:

- Reduces source water requirements by 50%.
- Seals natural fractures, thus serving as a fluid-loss additive.
- Nitrogen in the foam enables faster flowback for fast cleanup.
- Foam allows for higher proppant concentration at lower pump rates.

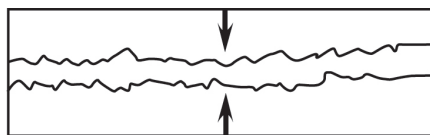
Photo below shows a typical wellhead used for both foam fracs and gas fracs.

Fracturing With N₂ Only (gas fracs)

Operators have had success pumping nitrogen (N₂) at very high rates (240,000 scf/min or more). High rates were used to achieve maximum stimulated reservoir volume (SRV), for enhancing production economics, and to achieve greater estimated ultimate recovery (EUR).

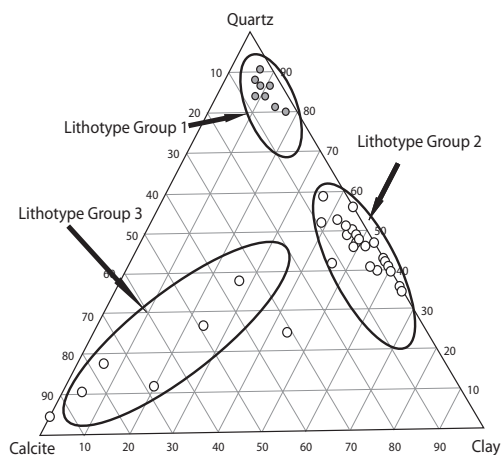
Achieving both SRV and greater production is due in large part to reservoir pressure plus a combination of rock and fluid properties. Nitrogen provides a more pulse-like pressure wedge caused by the duration of nitrogen exposure to the formation, which also limits the volume of N₂ leaked off to the ultra-low permeability shale/siltstone lithologies. Where wells are underpressured, they are difficult to unload when using water for fracturing. Fracture stimulation of such wells by pumping straight N₂ at maximum rates ranging from 180–240,000 scf/min is a viable option.

No proppant or fracturing fluid is used in the stimulations. Brittleness and resultant “plume” structures created on the rock face are the properties that make stimulation without proppant or frac fluid feasible. The sketch below shows a conceptual view of a fracture face resulting from high-pressure N₂ pumping; the natural rugosity of the fractured “plume” surfaces holds the fracture open to provide flowpaths for gas production.

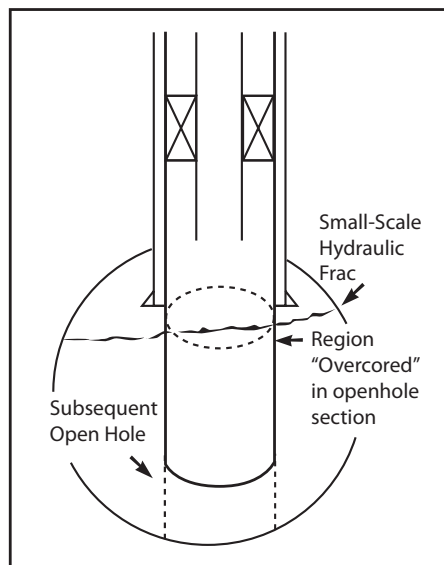


Natural gas-frac rugosity eliminates need for proppant in the fracture.

As shown below, the potential of a formation to respond favorably to a nitrogen-only frac can be determined through analysis of the target formation lithotypes via cuttings or core analysis (see ternary diagram). In addition, test boreholes can be evaluated by (1) fracturing the open hole below the casing, (2) drilling or coring through the fractured zone, and (3) running SWSI's OPTV formation imaging tool to directly image the resultant fracture system created. If the rock has fractured in a way similar to that shown, and the fracture remains open from its natural brittleness and fracture-face rugosity, the formation will likely be a candidate for nitrogen-only fracturing.



Lithotype grouping of shale based on mineralogy.



Retrieving a core sample that has been fractured by a small-scale hydraulic frac.

N₂ Unit Availability

SWSI has N₂ units in these locations, and can reach any point in the continental USA to serve your nitrogen frac needs.

Fredonia, PA
724-475-4881

Rusty Hite
724-541-8329

Bob Ostrode
724-541-7420

Jane Lew, WV
Kevin Hudson
304-884-6684

Kimball, WV,
Steve Stowers
304-585-7520

Norton, VA
Ray Wiles
276-679-5860

Gaylord, MI
Mike Brown
989-705-8301

Cottondale, AL
Greg Weathers
205-556-4542

Farmington, NM
John Youngstrom
505-801-5551

Van Buren, AR
Mark Pendergrass
479-471-7467



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