## TERRAFORM™ Drilling Fluid System

# THE MULTI-PURPOSE SOLUTION FOR MAXIMUM ASSET VALUE

Whether used in drilling a high-temperature wildcat in a sensitive ecosystem or in a low-solids and non-damaging drill-in application, NOV FluidControl's remarkably versatile TERRAFORM drilling fluid system is the single-drum solution for getting the highest possible yield from your well.

In the most demanding applications, our uniquely formulated TERRAFORM system time and time again delivers nearly oil-based comparable drilling rates while generating the minimal to zero skin required for maximum production. With TERRAFORM, we've even been able to eliminate the parasite strings often required for the most reactive formations. All this with the environmental benefits and reduced costs of a water-based drilling fluid.

The core of TERRAFORM is the industry's only non-concentrated biopolymer specially formulated to singularly push well beyond temperature boundaries once deemed impossible for a non-invert emulsion drilling fluid. TERRAFORM combines temperature stability up to 340°F with the superb inhibitive characteristics of potassium and the additional inhibition and lubrication of the formate. The end result is a high-density, low-solids system that consistently exhibits dependable rheological profiles and eliminates the non-productive time spent dealing with an unstable wellbore. This in a multi-use system that also is minimally corrosive, extremely CO2 tolerant, non-damaging, easy to maintain, compatible with a wide range of fluids and exhibits excellent suspension and lubricity characteristics.

As an added bonus, TERRAFORM comes with the industry-leading expertise of NOV FluidControl. As the recognized experts in TERRAFORM we can modify the system to provide a cost-effective solution for any conceivable application you may have.

### Applications

- Unconventional shale and other onshore wells
- Drilling and drill-in
- High-temperature wells
- Severe loss circulation zones
- Highly reactive formations
- Extended-reach drilling
- Sensitive ecosystems
- $H_2S$ and $CO_2$ environments

**Features**

- Proprietary HT biopolymer
- Robust inhibitors
- Minimal solids
- Low coefficient of friction values
- Minimal to zero skin
- Buffered against acid gases
- Superb caliper logs
- Excellent suspension characteristics
- Chloride-free
- Consistent, reliable rheologies
- Requires no spacers
- Deposits thin filter cake

**Benefits**

- High temperature stability
- Zero fluids-related NPT
- Increases ROP

- Produces near-gauge wellbores
- Negates effects of CO2 and H2S
- Zero cross-contamination
- Eliminates need for parasite strings
- Delivers excellent hole cleaning, lubricity
- Non-damaging
- Optimizes production
- Environmentally friendly
- Compatible with other fluids
- Requires minimal treatment
- Delivers stable wellbore
- Enhances wellbore stability
- Effective wide range of densities
- Reduces well construction costs

## $CO_2$ Contamination Test

| 14.5 LB/GAL | BEFORE $CO_2$ | AFTER $CO_2$ |
|---|---|---|
| $OH^-$ | None | None |
| $CO_3^{2-}$ | 2,604 | 918 |
| $HCO_3^-$ | 8,662 | 14,387 |

*After contamination, the buffer consumed and negated the effects of $CO_2$ as indicated by the free carbonates (918) that remained afterwards.*

**A drilling fluid that takes 'green' to an entirely new dimension**

TERRAFORM contains no chlorides making it entirely environmentally friendly and, as closed bottle aerobic biodegradability tests confirm, completely biodegradable. Consequently, drill solids from the environmentally friendly TERRAFORM can be discharged on-site where permissible. For you, this means eliminating the ever-rising costs of transporting drill wastes to approved disposal sites that in some shale plays can be 100 miles or farther from the drilling location. As importantly, TERRAFORM helps elevate your environmental profile in the communities in which you operate.

Between reducing waste management expenses, eliminating parasite strings in highly reactive reservoirs, rewriting days vs depth curves to slash well construction costs and increasing production, little wonder more operators turn to TERRAFORM, often when competing systems have failed to make the grade.

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**In the most challenging applications, the results speak for themselves**

In applications as diverse as building a high-angle curve to maximizing production in an unstable reservoir, TERRAFORM routinely reinforces its reputation as the high-performance workhorse of the drilling fluid industry. In every measurement of drilling fluid performance, TERRAFORM scores off the charts.

- **Temperature stability:** When incorporated in either brine or freshwater, our proprietary HT biopolymer allows us to engineer the TERRAFORM system with working and transition temperature limits up to 340°F, far beyond those possible with an ordinary biopolymer or xanthan. Amazingly, the TERRAFORM even maintained temperature stability when the industry standard 16-hour test was pushed to 30 hours to simulate a round trip in a deep well.
- **Inhibition:** Owing to the inherent inhibition of the potassium and formate, the TERRAFORM system heads off wellbore instability even in the most reactive shales. In dispersion tests, our distinctive TERRAFORM system has produced cuttings that retain their shape and strength. In comparative 16-hour axial swelling tests, TERRAFORM shows significantly lower swelling than both a 4% KCl solution and a high-performance clouding glycol-based shale drilling fluid. In addition, the excellent calliper logs TERRAFORM routinely affirms its capacity to produce a wellbore that is stable.
- **Rheology:** In densities up to 15 lb/gal, TERRAFORM consistently maintains a stable rheological profile. What's more, the system produces the 6 RPM readings necessary to reduce sag and deliver outstanding suspension characteristics. These inherent properties combine to facilitate efficient hole cleaning, even in ultra-long laterals.
- **Lubricity:** In metal-to-metal and metal-to-sandstone comparisons, TERRAFORM produces coefficient of friction values that stack up favourably with even those of ultra-lubricating diesel base systems.
- **$CO_2$ tolerance:** The TERRAFORM system remains unfazed even under excessive CO2 contamination. Astonishingly, following a 16- hr hot roll at 300°F, a buffered TERRAFORM system remained intact after contamination with four 'whip-it' cartridges of CO2 and even displayed excess buffer afterwards.
- **Corrosion:** When formulated as a drilling fluid TERRAFORM is minimally corrosive. To head off H2S embrittlement in sour gas environments, the system effectively tolerates a range of scavengers, including zinc oxide, with none of the adverse effects seen in other systems. What's more, the capacity of TERRAFORM to endure CO2 contamination unscathed prevents the formation of corrosion-causing carbonic acid.
- **Fluid compatibility:** TERRAFORM is compatible with a variety of saturated brines, including halides. Since it is not surface active and contains no surface-active additives, the system exhibits no emulsification tendencies in the presence of base oil. As a result, spacer fluids may not be necessary when displacing with a TERRAFORM system.
- **Non-damaging characteristics:** When TERRAFORM is formulated as a drill-in fluid, the formate serves as the brine and when combined with clarified xanthan and starches generates minimal to zero skin, thereby optimizing production. What's more, NOV FluidControl's formulation of an aerated 8.3 lb/gal TERRAFORM drill-in fluid for use in a highly reactive reservoir requiring perforations eliminated a parasite string while using only acid soluble lost circulation material to restore complete returns.

## TERRAFORM properties after 16-hr hot roll at 300°F

| DRILLING FLUID PROPERTIES | | |
|---|---|---|
| Density (ppg) | 11.5+ | 14.5 |
| Dial Readings | | |
| 600 | 57 | 82 |
| 300 | 33 | 47 |
| 200 | 27 | 25 |
| 100 | 18 | 16 |
| 6 | 5 | 7 |
| 3 | 5 | 5 |
| Plastic Viscosity | 24 | 35 |
| Yield Point | 9 | 12 |
| Gel, Initial | 4 | 4 |
| Gel, 10 min | 6 | 9 |
| API Fluid Loss | 6.3 | 4.8 |
| HTHP Fluid Loss | 18.0 | 13.8 |
| Temperature | 300°F | 300°F |
| Pressure | 500 psi | 500 psi |

NOV FluidControl provides a comprehensive portfolio of high performance, environmentally friendly drilling and completion fluid systems and additives, all engineered to optimize drilling efficiency, reduce non-productive time (NPT) and maximize production and the overall value of your asset. Our aqueous and invert emulsion drilling fluid systems in tandem with our talented and highly experienced fluid specialists ensure the delivery of cost-effective solutions for your most demanding offshore and onshore applications.

What separates NOV FluidControl from the rest is the unequalled, solutions-driven technical expertise we bring to each project. Throughout the process, our specialists work closely with the client to define well objectives and make sure they are met. To that end, we rely on a wide range of services that include well planning and analysis, unmatched wellsite monitoring of fluid properties, office-based technical support as well as supplementary technologies such as offshore mud coolers and non-damaging reservoir drill-in fluids.

*To learn more about the extremely versatile TERRAFORM potassium formate drilling fluid system and how it can help meet all your drilling environmental and economic objectives contact your nearest NOV FluidControl representative.*

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