Gravel pack technology solutions

Improve gravel pack operational efficiency, completion productivity and pack integrity

Integrated technology solutions that improve gravel packing efficiency, completion performance and well productivity.

CARBO portfolio of proppant and sand control technologies, individually or as an integrated solution, deliver multiple improvements to the performance of your gravel pack and fracpack productivity & operational efficiencies.

- Confirm productive zone coverage
- Evaluate gravel pack quality and identify voids
- Identify gravel pack failures
- Efficient gravel pack placement and avoid formation fracturing
- High permeability for minimal pressure drop
- Consistent sand retention performance
- Improve Alpha-Beta gravel placement performance and lower pumping pressure
- Increase integrity of high-injection and production rate wells
- Protect sensitive completion equipment
- Create a high integrity gravel pack in low compressive environments
- Avoid gravel pack washout, voids and loss of completion
- Inject and produce at higher rates
- Long-term, cost-effective production assurance

Key technologies

CARBOAIR / KRYPTOAIR
High-transport, ultra low-density ceramic proppant technology

FUSION
Proppant pack consolidation technology

CARBONRT GP
Inert tracer technology for gravel pack applications

CARBOTAG
Chemically-tagged traceable technology

GUARD
Proppant-delivered production assurance technologies

KRYPTOSHPERE LD
Ultra-conductive, low-density ceramic proppant technology

CARBO

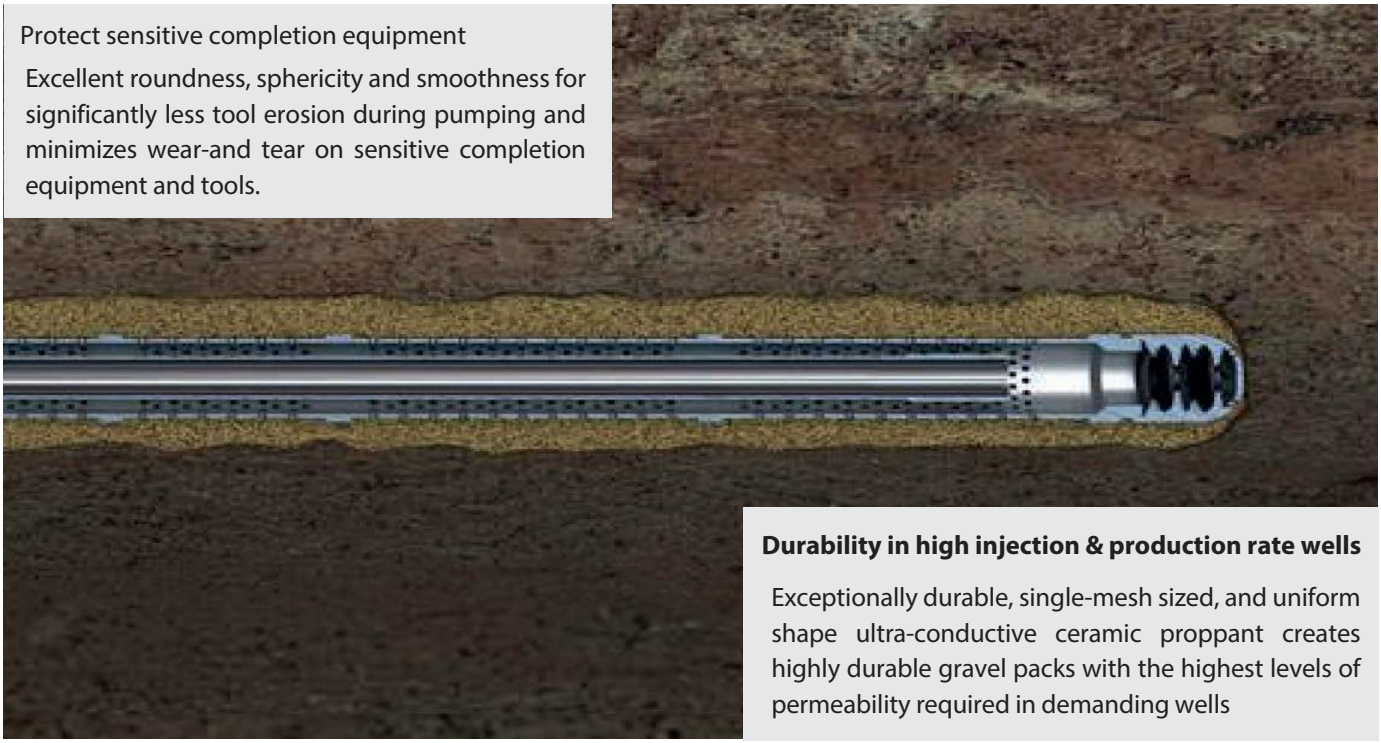
Production. Enhanced.

KRYPTOSPHERE LD

Create an ultra-high conductivity gravel or frac pack to maximize productivity

Protect sensitive completion equipment

Excellent roundness, sphericity and smoothness for significantly less tool erosion during pumping and minimizes wear-and tear on sensitive completion equipment and tools.



Durability in high injection & production rate wells

Exceptionally durable, single-mesh sized, and uniform shape ultra-conductive ceramic proppant creates highly durable gravel packs with the highest levels of permeability required in demanding wells

KRYPTOSPHERE LD ultra-conductive, low-density ceramic proppant

KRYPTOSPHERE® LD ultra-conductive, low-density ceramic proppant technology significantly exceeds the conductivity, compressive strength and durability of most conventional ceramic proppants. The improved performance is comparable and often exceeds the performance of intermediate density and bauxite ceramics while delivering the improved transport characteristics of a low-density proppant.

The Mean Particle Diameter of single-mesh KRYPROSPHERE 20, 25 and 35 approximates that of equivalent 16/30, 20/40 and 30/50 regular mesh. Sand retention testing has proven equivalent sand retention for KRYPTOSPHERE compared to equivalent mesh sizes.

Features and benefits in gravel and frac pack applications

- Exceptional strength and durability maintain the highest flow rates and levels of permeability for the life of the well
- KRYPTOSPHERE LD can be manufactured to any size required to suit sand control and well completion requirements
- Creates a gravel pack with more space to flow. More uniform pore throats reduce the pack tortuosity resulting in lower non-Darcy and multiphase pressure losses
- Improved proppant transport compared to bauxite based intermediate and high density ceramics for efficient gravel pack placement. The lower density also enables utilizing lower viscosity fluids and lower pump rates
- Single-sized KRYPTOSPHERE proppant particles create a more stable pack less prone rearrangement that may create voids compared to standard proppant

The switch to KRYPTOSPHERE LD maximizes productivity in the Caspian Sea

An operator in the Caspian Sea typically used light weight Ceramic proppant (LWP) in their sand control completion in high rate oil wells. Depending on the reservoir conditions the well architecture ranged from open to cased hole either utilizing gravel packs or fracpacks as the sand control method. Given the high permeability of these reservoirs the operator switched to KRPTOSPHERE LD ultra-conductive proppant to maximize the well productivity. KRYPTPSPHERE LD single mesh, smooth surface and internal microstructure characteristics reduce non-Darcy and multiphase flow pressure loses as well as conductivity degradation due stress cycling unlocking the full reservoir potential.

CARBOAIR/KRYPTOAIR

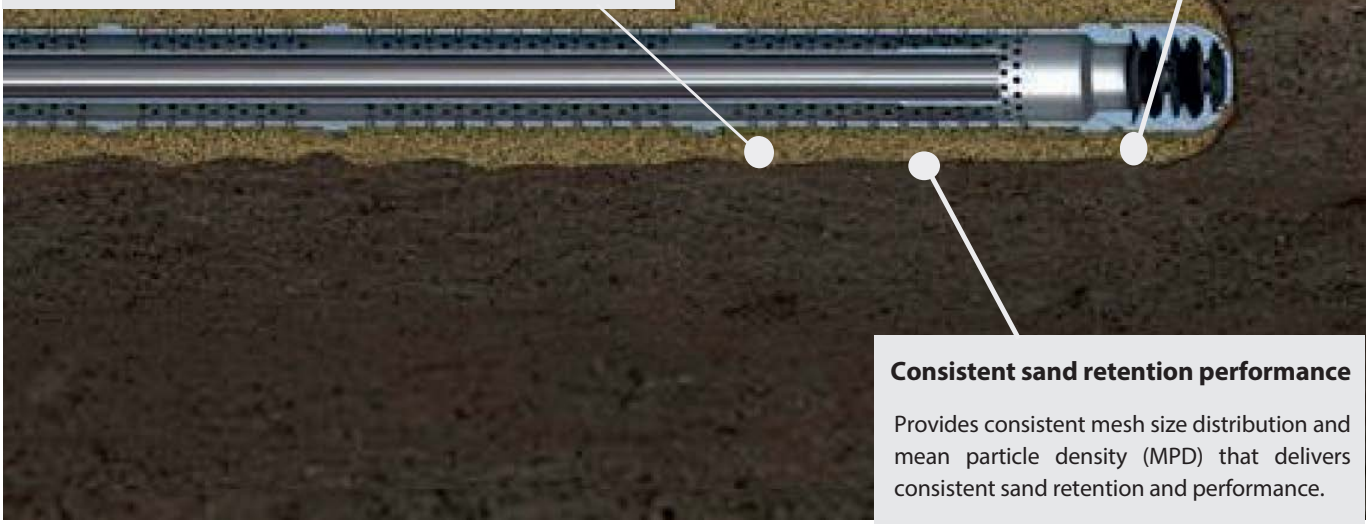
Efficiently create a high-quality gravel pack for improved well productivity

Efficient gravel pack placement at low pumping pressure

The excellent proppant transport characteristics of CARBO's AIR technology enables lower fluid viscosity and pump rates to be used. This allows efficient pack placement and the full packaging of the annulus while avoiding fracturing the formation. The reduced fluid viscosity and pump rates are critical in wells with low frac pressure and/or a low working window between between frac and formation pressure. These conditions are typical in many shallow unconsolidated formations that require gravel packing for sand control.

Ideal for Alpha-Beta gravel packing in operations

The Alpha-Beta wave technique is typical in gravel pack operations with straight or slick water in horizontal or highly deviated wells. In these operations, the pump rate, carrier fluid viscosity and proppant density determine the height of alpha wave and pressure applied to the formation throughout the treatment. As an ultra-low density ceramic proppant, CARBO's AIR technology lowers the height of the alpha wave leaving more space above it to place the beta wave. This reduces the pressure, preventing fracturing the formation.



Consistent sand retention performance

Provides consistent mesh size distribution and mean particle density (MPD) that delivers consistent sand retention and performance.

CARBO's AIR Technology high-transport, ultra low-density ceramics proppant technology overview

CARBO's AIR Technology enables operators to efficiently create a high-quality gravel pack at low fluid viscosity and pump rates. The lower rate and viscosity help to maintain the formation under control and prevent fracturing it in wells with a tight reservoir and frac pressure window.

Under radial flow conditions in a gravel pack completion where all production is passing through the pack, and perforation tunnels in cased hole, any impairment to pack permeability has a significant negative impact on well productivity. Gravel packing with CARBOAIR® and KRYPTOAIR® technologies has a high impact on completion efficiency resulting in a minimal completion skin and impairment to well productivity

Applications

- Cased hole and open hole gravel packing in vertical, deviated and horizontal wells
- Gravel packing in low frac gradient and narrow frac formation pressure window environments
- Multi-path screen horizontal open hole gravel pack applicationswhen using erosion-sensitive completion hardware

Features and benefits in gravel pack applications

- Ultra low-density ceramic proppant with chemically engineered internal porosity that exceeds the conductivity, strength and durability of sand
- CARBOAIR apparent specific gravity of 2.0; approximately 25% lower than sand, resin-coated sand (RCS) or low-density ceramic (LDC)
- Enhanced transport characteristics: 30%-40% slower settling rates compared to sand, RCS and LDC
- KRYPTOAIR® specific gravity of 1.6 provides an even lighter density proppant and enduring slurry density resulting in 40% lower density and 60% lower settling rate compared to sand, RCS and LDC

Effective completion of a long open hole gravel pack in the North Sea

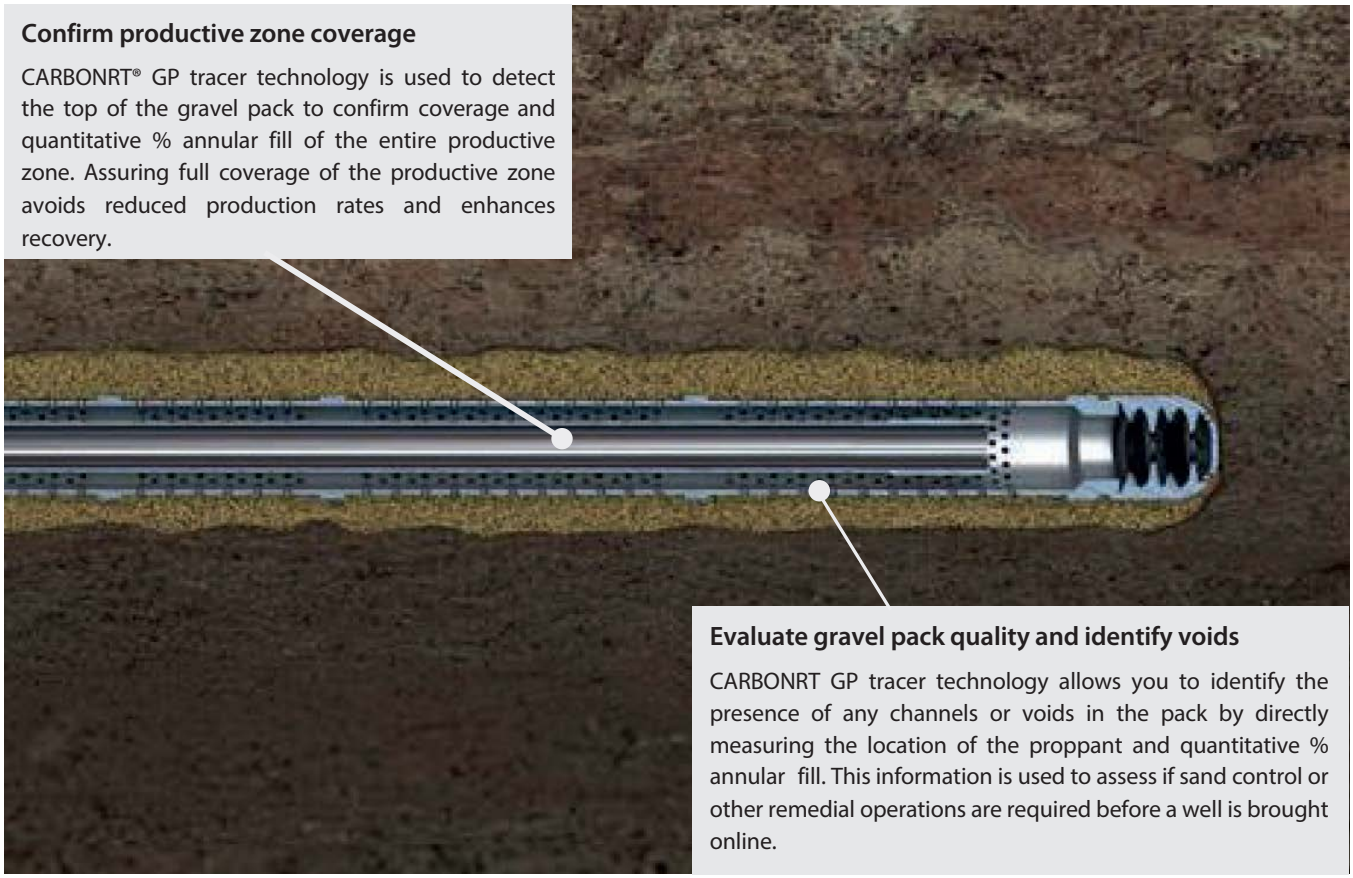
A full annular pack was achieved in a challenging well with uphill heel to toe trajectory with a maximum angle of 103^{0} and 250ft up dip over the length of the lateral. CARBOAIR technology enabled effective gravel transport at lower pumping rates without breaking down and damaging the formation.

CARBONRT GP

Safe, environmentally responsible, accurate and cost-effective

Confirm productive zone coverage

CARBONRT® GP tracer technology is used to detect the top of the gravel pack to confirm coverage and quantitative % annular fill of the entire productive zone. Assuring full coverage of the productive zone avoids reduced production rates and enhances recovery.



Evaluate gravel pack quality and identify voids

CARBONRT GP tracer technology allows you to identify the presence of any channels or voids in the pack by directly measuring the location of the proppant and quantitative % annular fill. This information is used to assess if sand control or other remedial operations are required before a well is brought online.

CARBONRT GP inert tracer technology overview

CARBONRT® GP inert tracer technology for gravel pack applications has been developed to enable a safe, accurate and cost-effective evaluation of gravel pack completed wells. The technology is combined with any CARBO ceramic proppant and manufactured with a proprietary tracer uniformly distributed throughout each proppant grain. The tracer is permanently detectable, so evaluations can be performed and repeated at any time during the life of the well to monitor pack quality. The technology is used in cased hole and open hole completions in both vertical and horizontal wells to help you increase production and recovery.

Identify gravel pack failures

Gravel pack failures can be identified by detecting the absence of the CARBONRT GP tracer. Understanding the location of any failures can be used to guide remedial operations. As a permanent tracer periodic logging runs can be used to evaluate pack integrity over the life of the well.

Features and benefits in gravel pack applications

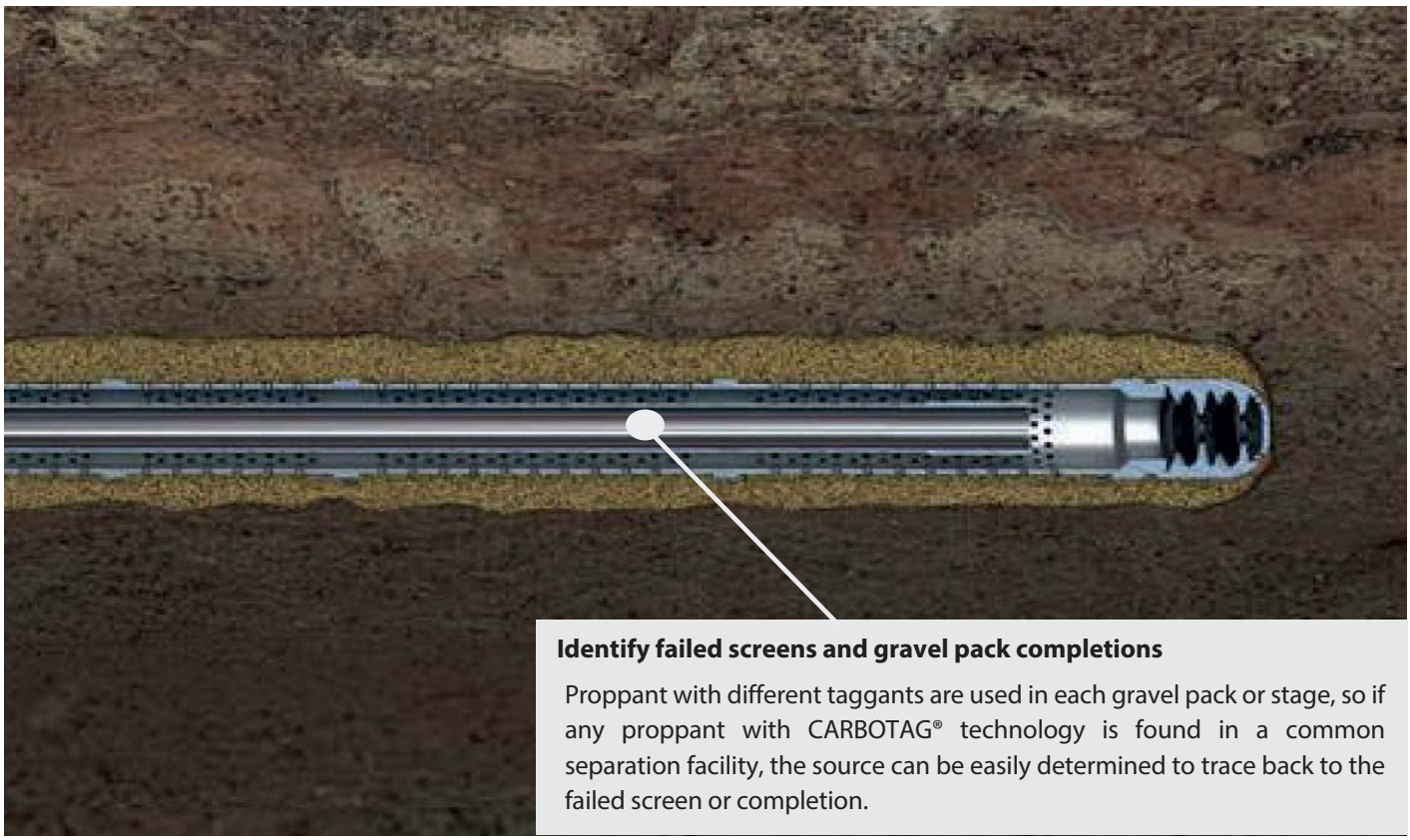
- Inert, permanent tracer that is safe and environmentally friendly - no special equipment, handling, permits or licenses required
- Uniform distribution of tracer within each proppant grain - not a coating - cannot be dissolved or washed away
- The consistent distribution of the tracer throughout the gravel pack enables a highly accurate evaluation of gravel pack top and quantitative % annular fill
- Detected using pulsed neutron logging tools run at standard speeds
- Can be manufactured into any CARBO ceramic proppant and does not affect the physical properties

CARBONRT GP helps evaluate gravel pack quality

A well in south-west Canada was completed with a cased hole GP with 3 ½" base pipe wire wrapped screens and blanks in 7.0" casing. The CARBONRT evaluation allowed to clearly identify the top of the fill covering the screens and 35' of blank pipe. The quantitative evaluation determined a 95% to 100% fill and 95% to 100% annular fill across the 115" of screens.

CARBOTAG

Determine the source of proppant flow back from failed screens and completions



Identify failed screens and gravel pack completions

Proppant with different taggants are used in each gravel pack or stage, so if any proppant with CARBOTAG® technology is found in a common separation facility, the source can be easily determined to trace back to the failed screen or completion.

CARBOTAG chemically-tagged traceable technology

CARBOTAG® chemically-tagged traceable technology is a patented process to add unique chemical markers —called taggants—to any CARBO proppant during manufacturing. The taggants are naturally occurring chemical markers. Since they are nonradioactive, they do not present any health hazards, nor any additional handling requirements. The taggants are added in trace concentrations during the manufacturing process and do not alter the physical properties or performance of the proppant. The taggant can be easily identified with routine chemical analyses of a flowback sample, including x-ray fluorescence (XRF) and inductively coupled plasma (ICP) analysis.

Features and benefits in gravel pack applications

- More than 20 unique chemical taggants available
- Taggants do not degrade over time
- Does not alter the physical properties or conductivity of the proppant

CARBOTAG enables identifying the source of gravel pack failure in commingled production from GoM wells

A GoM Operator had experienced screen failures in multistage fracpack wells. Commingled production through a common subsea manifold forced to a costly trial and error approach to identified the failed well and zone. CARBOTAG was incorporated in the next 3-stage fracpack completion to enable pinpointing the offending zone in the event of a future failure. Analysis of production samples would enable identifying the failed screen saving costly sequential well shut-in and intervention.

FUSION

Increase gravel pack integrity to remove unnecessary injection or production rate limitation

FUSION proppant pack consolidation technology

FUSION® proppant pack consolidation technology allows you to create a bonded, high integrity gravel pack without closure stress or elevated temperature. The technology provides you with the integrity critical for gravel packs, especially in ultra-high injection and production rates wells. FUSION also incorporates CARBONRT® Technology, enabling the evaluation of the integrity of the pack for the life of the well.

Avoid gravel pack washout, voids and loss of completion

FUSION technology improves well productivity by preventing proppant washout from the non-compressive annulus and near-wellbore areas. These areas lack the compressive forces to hold in place or bond conventional resin-coated proppant which can lead to voids, channels and in worst case scenarios the complete loss of the completion.

Create a high integrity gravel pack in low compressive environments

FUSION technology features durable, high conductivity ceramic proppant with a proprietary resin coating which enables controlled bonding of the gravel pack using a unique chemical-activator. The chemical-activated bonding process forms a strong, flexible bond without compression even in low temperature environments to create a high integrity pack that withstands stress cycling to sustain long-term pack integrity.

CARBO's FUSION technology is compatible with most gravel pack and frac fluids

FUSION deployed in high rate water injectors with fracpacks to maintain wellbore connectivity in GoM

High injection rates in power injector wells often exceed frac pressure. This leads to overflushing the fracpack, losing connectivity and injectivity to the target zone. FUSION technology was implemented in four wells to prevent these issues and sustain the projected rates of injection over time. All four wells we successfully completed and have been injecting over 50,000 BWPD with no issues for more than 2 years. This project earned an excellence award for most valuable project on a global from the E&P operator.

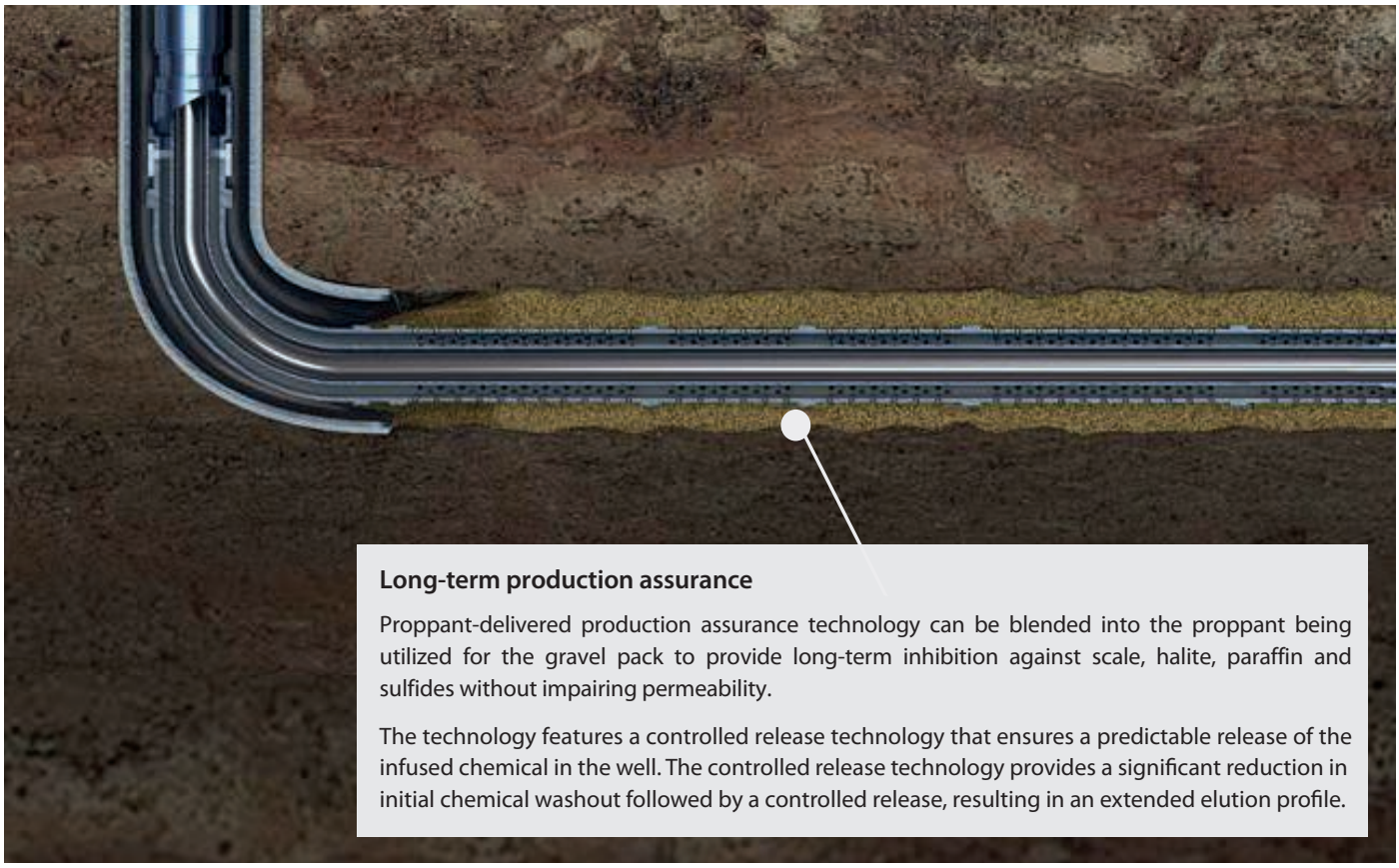
Features and benefits in gravel pack applications:

- Complete technology system of high-quality, high durability ceramic proppant, inert tracer technology, unique chemical activator and proprietary coating technology
- Gravel pack placement and integrity can be evaluated at any time during the life of the well
- Permanently detectable CARBONRT inert tracer technology is manufactured into the substrate of every proppant grain
- Simple operation and clean-up unique bonding process is chemically-activated, any excess proppant in the work string after the pumping can be reversed out prior to pack bonding
- Creates "in wellbore" gravel packs to repair wellbores with casing damage or enlarged perforations and producing solids

With FUSION technology, E&P operators are no longer required to limit water injection rates to protect the integrity of the annular pack and safeguard the well. This removes previous unnecessary limitation which reduced production rates and estimated ultimate recovery (EUR) from the reservoir.

GUARD

Long-term, cost-effective assurance against multiple production issues



Long-term production assurance

Proppant-delivered production assurance technology can be blended into the proppant being utilized for the gravel pack to provide long-term inhibition against scale, halite, paraffin and sulfides without impairing permeability.

The technology features a controlled release technology that ensures a predictable release of the infused chemical in the well. The controlled release technology provides a significant reduction in initial chemical washout followed by a controlled release, resulting in an extended elution profile.

SCALEGUARD®: Carbonate and Sulfate scale prevention
SALTGUARD®: halite deposits suppressant
PARAGUARD®: paraffin deposits prevention

GUARD proppant-delivered production assurance technologies overview

GUARD proppant-delivered scale-inhibiting technology is a porous ceramic proppant engineered with an innovative controlled release technology and infused with production assurance chemicals.

An engineered, uniformly distributed, interconnected porosity maintains the critical strength of the proppant while making it an effective chemical delivery mechanism. As the chemical is infused in a uniform manner throughout the porosity of the proppant pellet, you can place larger volumes of chemical in the gravel pack of fracpack than you would experience with surface adhesion.

The technology is a highly efficient, effective and simple way to protect your gravel pack and well from production issues. As production flows past the GUARD proppant it picks the infused chemical preventing the precipitation of damaging deposits.

Features and benefits in gravel pack applications:

- Places a highly effective production assurance treatments directly into the gravel pack—with no impact on conductivity.
- GUARD technologies can be either delivered pre-mixed with CARBO proppant, or blended onsite with any other proppant.
- Protects against multiple production assurance issues in a single treatment during gravel pack operations
- Outperforms other production assurance treatments such as particulate carriers, chemical squeezes, continuous chemical injection and water injection for cost and long-term effectiveness
- The technology also provides improved carrier fluid compatibility
- No impact on gravel pack permeability or integrity
- Mitigates Production Decline caused by damaging deposits
- Minimizes shut-ins, downtime and deferred production.