The SandWedge® conductivity enhancement system is used in conjunction with propped fracturing. The system chemically modifies the surface of the proppant grains to provide several important benefits:

- Helps maintain a high well production rate for a longer period of time.
- Stabilizes the proppant pack/formation interface to help reduce the intrusion of formation material into the proppant pack.
- Enhances frac fluid clean-up.
- Reduces proppant settling to help improve permeability of the proppant pack.
- Reduces the effects of diagenesis.
- Compatible with all water-based fracturing fluids, including seawater.
- Meets the requirements of wells up to 350°F.

SandWedge Enhancer Can Help Improve Production from Virtually Any Fracturing Treatment

Recent field results have shown that virtually any viable, productive well that is fracture stimulated will produce more hydrocarbons for a longer period of time if SandWedge enhancer is added to the proppant. Use of SandWedge agent helps address these issues:

- Accelerated or abnormal production decline.
- Bottomhole assembly clogged with fines or formation material.
- Fracturing treatment involves a fines-laden proppant sand.
- Rate of reservoir production needs to remain same, but with less pressure drop.
- More aggressive reservoir production is required, but with less damage.

SandWedge Enhancer Can Be Tailored to Meet Treatment Requirements

Based on what reservoir problems exist (fines, rapid production decline, etc), SandWedge Lite, Plus, and Max services are available. Each system can be formulated to meet a variety of treatment requirements.

For most wells with BHT up to 350°F with the primary focus being long term conductivity, control of fines migration and improved production, a formulation is designed for dry coating all the proppant on the fly.

For smaller treatments, a formulation is available that can be applied to the proppant in the blender tub (wet coating).

In areas where white fracturing sand is not available, a formulation can be applied to brown fracturing sand and provide results that are essentially the same as achieved with white sand without SandWedge enhancer.
• For the Gulf of Mexico (GOM) and certain other environmentally sensitive land and offshore areas, a formulation is designed to allow overboard discharge in the GOM in that it conforms to all overboard oil and grease limits set by the U.S. Minerals Management Service. It also meets the environmental requirements of key coalbed methane producing areas and has been approved for use in those areas.

• For water frac treatments where only a small amount of proppant is used, a SandWedge enhancer formulation is available that has been proved to help boost long-term production.

It is important to note that SandWedge agent is a conductivity enhancer, and is NOT a proppant flowback control additive. Halliburton’s Expedite® system helps control proppant flowback and enhances conductivity.

• For arctic conditions where the temperature of the proppant is extremely low, a formulation is also available.

How Does SandWedge Enhancer Help Prevent Intrusion of Formation Material?

Intrusion of formation material into the proppant pack is a major cause of production decline and increased operating expense. In addition to plugging pore throats, unabated intrusion of formation material (fines) can lead to geochemical precipitates that block conductivity paths in the pack. Expenses related to pump changes also may increase due to scale build-up and other by-products of fines intrusion.

SandWedge agent serves as a “maintainer” of conductivity and diminishes the effects of fines by 1) dispersing the effects of damage when trapping fines at the formation/proppant pack interface, and 2) maintaining proppant pack integrity, stabilizing the filtering mechanics. Figure 1 shows the stabilized proppant pack/formation interface achieved with SandWedge enhancer.

Where the impact of fines production is even greater such as in coalbed methane (CBM) wells, the improvements made possible by applying SandWedge enhancer may be even more pronounced.

Enhanced Proppant Pack Conductivity

Flow tests have shown significant increases in conductivity following application of SandWedge® enhancer (Figure 2). SandWedge agent enhances fracture conductivity of the proppant pack through several mechanisms:

Maximizes breaker efficiency. By coating the proppant, substantially encapsulating each grain, SandWedge agent helps prevent frac gel adsorption on the proppant surface. This enhances the effectiveness of gel breakers in reducing gel viscosity and promoting fracture cleanup.

Inhibits proppant settling. SandWedge agent reduces the proppant settling rate in the fracture resulting in enhanced vertical distribution of proppant and increased propped fracture height. Additionally, it inhibits proppant from settling into a tight, rhombohedral pack. This means more porosity and permeability.

Minimizes diagenesis effects. During production, the proppant and formation exist in a mineral-rich environment under heat and pressure. This can lead to diagenesis, resulting in the formation of deposits that can plug the pore spaces and reduce conductivity. Coating the proppant with SandWedge agent greatly reduces or eliminates diagenesis.

Reduces the impact of stress cycling. Stress cycling occurs, for example, when flow rates are changed or the well is temporarily shut in. This cycling causes the proppant pack to shift and enables formation material to intrude.
Case Histories

Case History #1 - Production rates from four offset wells were compared. The wells were offsets and had essentially identical completions except that the proppant in one of the wells was treated with SandWedge enhancer. Compared to the average production from the other three wells, the SandWedge-treated well produced more initially, maintained higher production and produced 50% more cumulative.

Case History #2 – Production history of two sets of virtually identical South Texas wells shows clearly that the fracturing treatments using SandWedge agent-coated proppant outperformed the wells fractured with sand only. These wells were all completed within a 60-day period and are served by a common gas gathering system. The increased production was worth over $250,000 per well per year.

Case History #3 – Three coalbed methane wells in the San Juan Basin (Four Corners area) were refractured using SandWedge service. The wells were studied in terms of the effect of SandWedge agent on advancing dewatering and overall production. All three wells responded significantly and provided fast payouts of the refracs. The graph at right is for well No. 2. Notice there is no production decline.

<table>
<thead>
<tr>
<th>Case</th>
<th>CBM Refrac 1</th>
<th>CBM Refrac 2</th>
<th>CBM Refrac 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gas produced 9 months after initial stimulation (MCF)</td>
<td>463,747</td>
<td>88,406</td>
<td>72,452</td>
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<tr>
<td>Delta gas 9 months after refrac (MCF)</td>
<td>179,071</td>
<td>408,818</td>
<td>268,294</td>
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<tr>
<td>At $2.50 per MCF</td>
<td>$447,677.50</td>
<td>$1,022,045.00</td>
<td>$670,735.00</td>
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<tr>
<td>ROI of refrac after 9 months (approximate)</td>
<td>3.37:1</td>
<td>9.22:1</td>
<td>5.71:1</td>
</tr>
<tr>
<td>Time to pay out of stimulation treatment</td>
<td>3 weeks</td>
<td>3 weeks</td>
<td>1.33 months</td>
</tr>
</tbody>
</table>
For more information about how SandWedge® Lite, Plus, and Max conductivity enhancement services can help improve the results of your fracturing treatments, contact your local Halliburton representative or email stimulation@halliburton.com.