INNOVEX

Putting You in the Zone

COMPOSITE CENTRALIZERS

FIBER-REINFORCED POLYMER (FRP)

EZEEGLIDER

OPTIMIZER

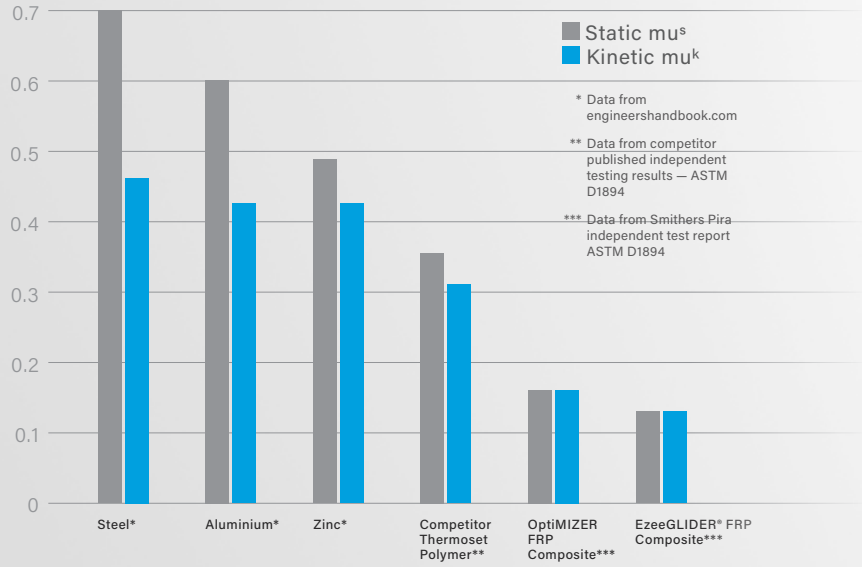
The Innovex Fiber-reinforced Polymer (FRP) Composite EzeeGLIDER® and OptiMIZER range of ultra-low friction centralizers are designed for slip on installation over casing or screens. FRP composites are commonly used in the aerospace, automotive, marine and construction industries, and as ballistic armor.

Innovex composite centralizers are designed for extreme temperature, high side load, high friction, abrasive, highly inclined, horizontal and extended reach wells. These composite centralizers provide a cost effective low friction alternative to traditional centralizers manufactured from steel, zinc and aluminum.

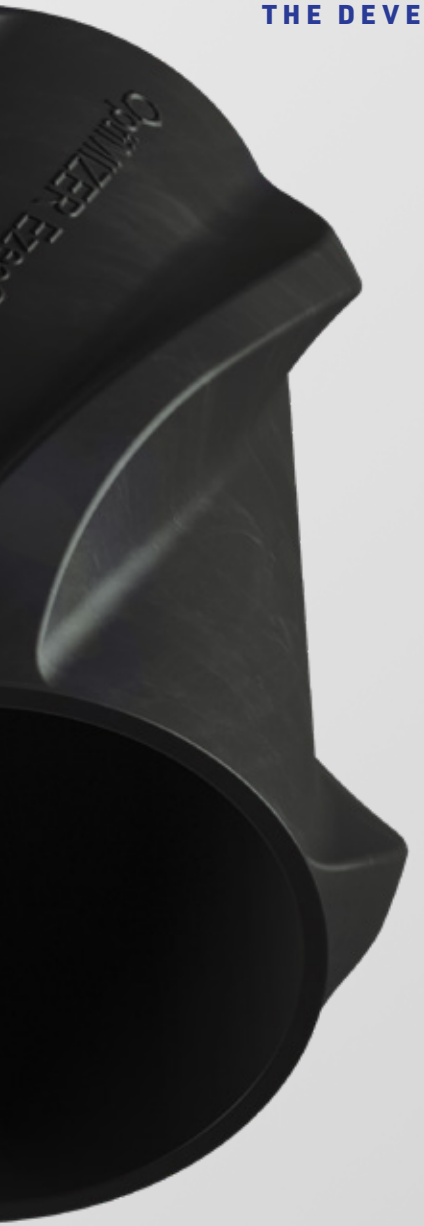
Innovex FRP composite centralizers provide the lowest friction coefficient of all polymer centralizers, providing significant advantages when used in high angle, horizontal and ERD well construction.

Independent consultants — Smithers Pira — tested our composite materials to establish the coefficient of friction. The results were determined using a method based on ASTM D1894-08 on a RDM flatbed friction tester. **Figure 1** compares the results with published coefficients of friction for other materials used to manufacture centralizers. Of key importance is not just the headline friction reduction but the negligible difference displayed between static and dynamic friction of Innovex composites which ensures our product is the easiest to start to move in the well and allows for more consistent rotational torque and reduced stick slip.

FIGURE 1 **FRICTION COEFFICIENTS (μ) OF MATERIALS ON STEEL (DRY)**



THE DEVELOPMENT OF THE POLYMER CENTRALIZER



Introduced in 2001, the **EzeeGLIDER** was the first centralizer manufactured from FRP composite. Extensive trials were conducted on numerous thermoset plastics and FRP composites to establish the characteristics required to produce quality tools.

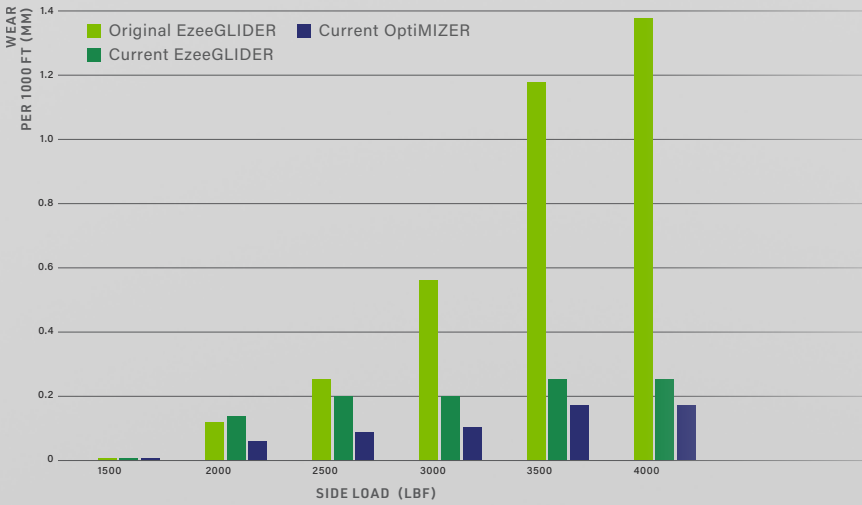
The result was the selection of a FRP composite containing long fibers providing exceptional strength, abrasion resistance and toughness far in excess of any base polymer.

Working with suppliers and customers, we are continually improving the performance of our centralizers, as new and superior materials become available to improve wear resistance, reduce friction and increase temperature and side load capacities. When Innovex composite centralizers were first introduced, casing side loads of 2,000 lbf were seen as a bench mark for wear resistance testing. With today's drilling parameters many wells now have casing side loads of between 3,000 lbf and 4,000 lbf. The graph in **Figure 2** demonstrates the improvement in wear resistance of our current composite materials — BOS21 and BOS11 — compared with our original composite selected in 2001.

Innovex's latest composites are significantly tougher when the side loads are in the range of 3,000 to 4,000 lbf.

In addition to the friction and wear characteristics of Innovex centralizers, another key feature is the exceptional strength and overall toughness.

FIGURE 2 **FRP COMPOSITE WEAR RATE TEST RESULTS**



The outcome of these tests prove the EzeeGLIDER has toughness far in excess of other polymers in the market and this can be seen in **Figure 7**.

This table summarizes the overall strength, toughness and low friction characteristics of Innovex composite centralizers. This demonstrates that the composite materials we currently use in the manufacture of the EzeeGLIDER and the OptiMIZER are superior to the physical characteristics of a typical thermoset plastic. Thermoset plastics may be produced which are extremely hard and have high impact resistance, however, they are often very brittle. An example of a thermoset plastic is the housing of a float valve which is extremely erosion resistant but is very brittle.

FIGURE 7 **HIGH STRENGTH POLYMER PHYSICAL COMPARISON MATRIX**

Properties	Test Standard	Units	Typical Thermoset Plastic	Innovex Ezee GLIDER Composite	Innovex OptiMIZER Composite
Specific Gravity	ASTM D792	g/cm3	1.03	1.56	1.55
Linear Mold Shrinkage	ASTM D955	inches	0.009 - 0.011	0.0015	0.007
Tensile Strength @ Yield	ASTM D638	psi	7,300	33,707	33,400
Tensile Modulus	ASTM D638	psi	260,000	2,364,111	2,470,000
Flexural Modulus	ASTM D790	psi	280,000	2,140,000	2,250,000
Flexural Strength	ASTM D790	psi	11,000	58,740	46,400
Compressive Strength (@ Yield)	ASTM D695	psi	8,788	39,600	37,600
Impact Strength Notched Izod @ 23° C	ASTM D256	ft-lbs/in2	14	14	7
Static Coefficient of Friction	ASTM D1894-08	μ	0.35	0.13	0.16
Kinetic Coefficient of Friction	ASTM D1894-08	μ	0.31	0.13	0.16
Heat Deflect. Temp. (264 psi)	ASTM D648	°C/°F	141/286	255/491	210/410

FIGURE 3

5.5" X 8.25" SPIRAL EZEEGLIDER COMPRESSION LOAD TEST

To ensure toughness we have subjected our centralizer to extensive axial and radial compressive testing. The results of this axial test presented in **Figure 3** and **Figure 4** demonstrates that the **EzeeGLIDER works effectively even when loaded with over 55,000 lbf of axial compressive force.**

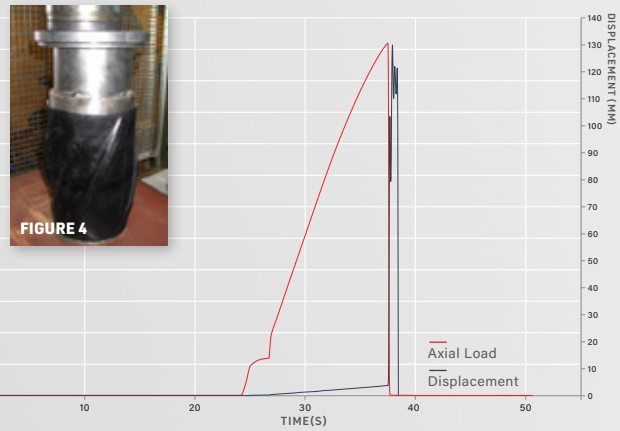
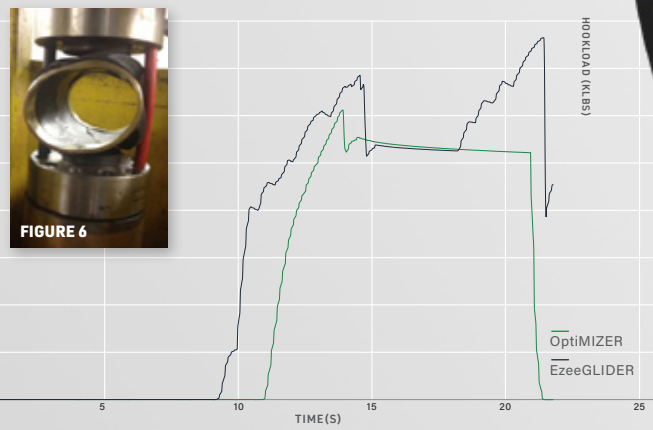


FIGURE 5

UNSUPPORTED SIDE LOAD COMPRESSION TEST RESULTS

Further testing was carried out to show the crush load the EzeeGLIDER would take before breaking while unsupported by casing. The results of the radial test presented in **Figure 5** and **Figure 6** demonstrate the **EzeeGLIDER works effectively even when unsupported and crushed with over 30,000 lbf of radial compressive loads.**



THE DEVELOPMENT OF THE POLYMER CENTRALIZER

The EzeeGLIDER and OptiMIZER centralizers were developed to address the challenges of deploying casings and completions in ERD, horizontal and high angle wells.

These main challenges are axial friction, radial friction, well bore tortuosity, dog leg severity, high side force and helical buckling. Our centralizers address these challenges and improve and assist by:

Reducing drag for running casings, liners or sand screens

Providing low friction high wear resistance gauge protection for lower completions

Reducing torque to rotate liners while cementing

Reducing overall casing or completions weight to aid flotation

Mitigating helical buckling by reducing torque and drag

Improving deployment of casings, liners or sand screens through casing windows and/or multilateral junctions

Features

Wear resistance, toughness, high thermal stability and high impact resistance

Ultra low static and dynamic coefficient of friction — resulting in lower start up torque to rotate due to small difference between static and dynamic friction and low coefficient of friction

Chemical inertness — no galvanic corrosion, thermal insulator and electric insulator

Melon shaped blades to ride over ledges

Choice of spiral 25 degree angle for cementing or passive 5 degree for open hole completions such as sand screens and packers

High compressive and tensile strength

Short compact design to fit onto screens

Lightweight

Benefits

Significant reduction in axial friction and radial friction

Rides over ledges and short design does not stiffen the string

Turns easily around high dog leg severity

Toughness and abrasion resistance to address high side force

Reduction in drag reduces helical buckling

Should casing or completion fail to reach TD then low drag aids removal from the well bore

Patented anti-swage rings on the EzeeGLIDER for high compression applications

Lightweight — improves manual handling

Assists passage through casing exits and multilateral junctions

Exceptional standoff providing zonal isolation

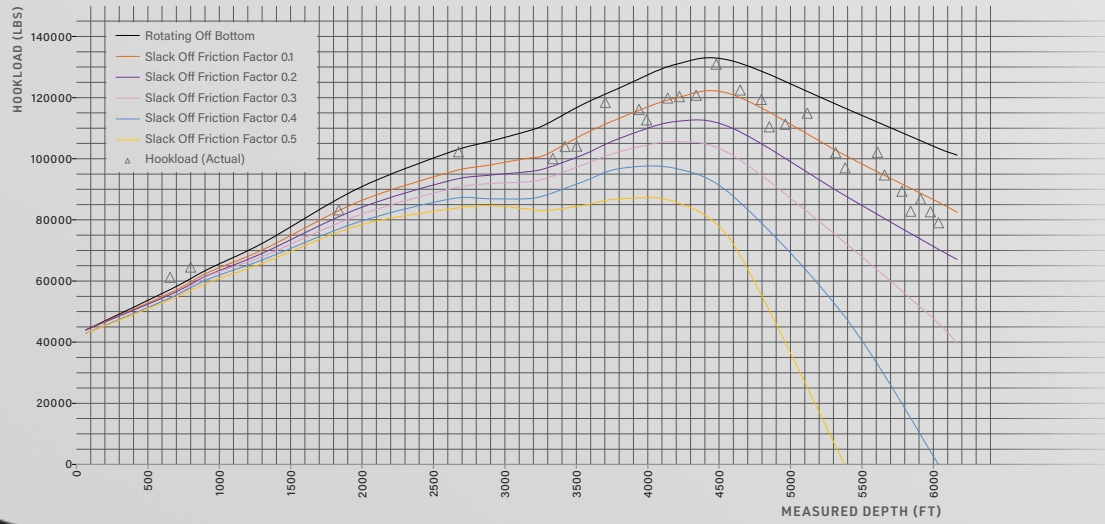
APPLICATIONS ENGINEERING

While many centralizer providers model an installation and provide standoff, torque and drag reports promising significant reductions in friction, our Applications Engineer use only the tangible benefit of the proven reduction in friction coefficient of composite materials.

As our composite is proven to have a 0.13 coefficient of friction, we can confidently reduce the drag running pipe by the difference in the coefficient of our product compared with an alternative centralizer material or with bare steel pipe. Our applications engineering team fully understands that quoted cased hole and open hole friction factors are an amalgam of friction, tortuosity, ledges and well bore condition as well as many other factors.

When Innovex models a casing or screen installation this is accounted for and we do not produce models promising any more than the resultant reduction in the friction coefficient of using our product.

FIGURE 8
122° FISH HOOK WELL. FINAL FRICTION FACTOR @ 122° = 0.12
The hook load plot presented in figure 8 is from a 122° fish hook well using EzeeGLIDER where a 7″ liner was installed in late 2006. The customer had previously experienced issues with hook load loss prior to the liner reaching TD. **This client had historically seen open hole friction factors in excess of 0.4 on all previous installations using steel centralizers and by using Innovex EzeeGLIDER the friction recorded was now 0.12.** This client continues to construct these fish hook wells today using Innovex EzeeGLIDER centralizers for his deviated casings and screen installations.



The EzeeGLIDER and OptiMIZER are the toughest, lowest friction FRP composite centralizers available today, and are engineered to cope with the increasing challenges the industry presents.

These composite tools were the first to the market in 2001, and lessons learned have resulted in a continuing development program to ensure an optimum product at all times.

INNOVEX

FOR ALL LOCATIONS PLEASE VISIT THE LOCATIONS PAGE ON OUR WEBSITE.

NORTH AMERICA

CORPORATE HEADQUARTERS
4310 North Sam Houston Parkway East
Houston, TX 77032
T: +1 346 398 0000
E: sales@innovex-inc.com

EAST TEXAS & LOUISIANA
1138 West Harrison Road
Longview, TX 75604
T: +1 903 759 2800

2212 Highway 662 N
Building C
Amelia LA 70340
T: +1 985 412 4980

FISHING TOOLS
1519 S. Flournoy Road
Alice, TX 78332
T: +1 361 396 0139

10938 Lucerne Street
Houston, TX 77016
T: +1 281 219 6613

601 McDonald Street
Odessa, TX 79761
T: +1 432 580 7414

1034 Forum Drive
Broussard, LA 70518
T: +1 337 492 5228

118 Common Court
Houma, LA 70360
T: +1 985 868 7333

2415 2nd Ave West
Williston, ND 58801
T: +1 701 572 0565

1294 South 1500 East
Vernal, UT 84078
T: +1 435 781 2856

SOUTH TEXAS
5746 Leopard Street
Corpus Christi, TX 78408
T: +1 361 452 2771

178 Oil Road
Pleasanton, TX 78064
T: +1 830 401 5887

MIDCONTINENT
17712 W. Hwy 33
Cashion, OK 73016
T: +1 832 775 9140

2709 S. Ann Arbor Ave
Oklahoma City, OK 73128
T: +1 405 491 2658

NORTHEAST
1848 Old Route 33
Weston, WV 26452
T: +1 304 841 0821

109 N. Madison Ave
Grove City, PA 16127
T: +1 724 605 1397

PERMIAN BASIN
9513 W. County Road 143
Midland, TX 79706
T: +1 979 314 3764

3111 W. 114th
Levelland, TX 79336
T: +1 806 215 7960

5910 S. County Road 1270
Midland, TX 79706
T: +1 432 999 4013

651 McDonald Street
Odessa, TX 79761
T: +1 918 445 0588

ROCKIES | BAKKEN
13 Town & County Lane
Williston, ND 58802
T: +1 701 353 3334

480 Basher Drive
Berthoud, CO 80513
T: +1 720 552 9982

600 17th Street, Suite
2800 South Tower
Denver, CO 80202
T: +1 601 218 3728

CANADA
Suite 1430, 250 6th Ave SW
Calgary, AB, Canada
T2P 3H7
T: +1 403 969 1415

4116-51 Avenue NW
Edmonton, Alberta,
Canada T6E 5V8
T: +1 780 433 9957
F: +1 780 472 2351

7720-17 Street
Edmonton, AB, Canada
T6P 157
T: +1 780 440 4440

LATIN AMERICA

MEXICO
Mexico City, Mexico
T: +52 55 5545 8111
M: +52 1 55 2668 1760

Carretera Villahermosa – Cárdenas Km 5.5,
Bodega M1L6B2, Interior Parque Logístico
Industrial Tabasco, Ria. Anacleto Canabal
4ta sección, Centro Tabasco, 86287
T: +52 9933 168887

COLOMBIA
Kra 100 No. 25 C 11 Bd 7,
Centro empresarial
Omega
Bogota, Columbia CP 110911
T: +57 1 756 1920

ARGENTINA
Espana 337 Cipolletti, Argentina
Luis Beltran 367 Neuquen, Argentina
T: +54 911 5643 4197

MIDDLE EAST & ASIA

UNITED ARAB EMIRATES
Office 2109, Jumeirah
Bay X3 Tower
Cluster X, Jumeirah Lake Towers, Dubai, UAE
PO BOX 333648
T: +971 4 454 8616

SAUDI ARABIA
7958 Abu Al Husan Al Zahrawy St.
Al Khalidiyah Ash Shamaliyah, Dammam
32231 3257
T: +966 13 814 6662

SULTANATE OF OMAN
Warehouse # 160Z, BBH Logistics City
Rusayl Industrial Area, Muscat,
Sultanate of Oman
T: +968 225070199

EUROPE, CASPIAN & AFRICA

SCOTLAND
1 Minto Place
Altens Industrial Estate, Aberdeen, Scotland
AB12 3SN
T: +44 1224 659 000

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