***BorFusion ®*** is Giant Coatings' proprietary boronizing process – during the ***BorFusion ®*** process, boron molecules react with iron in the steel and create an extremely hard surface layer known as Iron Boride (Fe2B). The diffused layer of Iron Boride penetrates the metal substrate in a tooth-like fashion creating an extremely tight bond that cannot flake, spall or chip away. Approximately 80% of the hardened layer will grow into the steel, leaving a mere 20% of surface growth. Depending on the type of material subject to the ***BorFusion ®*** process, the surface growth will vary – see the chart below for the approximate case layer thicknesses for various materials. Keep in mind the chart represents case thickness, not surface growth.

The ***BorFusion ®*** process results in a very hard surface that will minimize wear due to abrasion, corrosion, and erosion, not to mention the hardened surface has a low coefficient of friction allowing higher flow rates in many applications.

***BorFusion ®*** **can be applied on various different metals, including:**

- Carbon Steels
- Alloy Steels
- Stainless Steels
- Tool Steels
- Ni-Resist

***BorFusion ®*** is ideal on tools with minimum tolerances for surface growth which require excellent protection. As well it can be selectively applied to specific areas of tools including parts that have a complex geometry.

***BorFusion ®*** **Physical Properties**

| Material Type | Coating Thickness (inch) | Rockwell Hardness (HRC) |
|---|---|---|
| Carbon Steel | 0.002 to 0.006 | 76 to 80+ |
| Alloy Steel | 0.002 to 0.006 | 76 to 80+ |
| Tool Steel | 0.002 to 0.006 | 76 to 80+ |
| Stainless Steel | 0.0005 to 0.0015 | 71 to 80+ |
| Ni-Resist | 0.0005 to 0.0015 | 70 to 78 |

**Typical Applications**

- ✓ ESP & HPS Stages
- ✓ Isolation Sleeves
- ✓ Valve Components
- ✓ Rod Guides
- ✓ Profile Nipples
- ✓ Centrifugal Pumps
- ✓ Frac Subs
- ✓ Profile Slick Joints
- ✓ Much More!!!

**Recommended Services**

- ✓ Abrasive – Injection Services, Sandy Wells
- ✓ Corrosive – H2S, CO2, Chlorides
- ✓ Erosive – Slurry & Well Fracturing Applications

**Lab Testing**

Giant Coatings Ltd. conducts product tests on coupons to ensure quality and conformance is maintained. All testing performed by Giant Coatings Ltd. are contracted out to a third party testing facility, such as the Alberta Innovates - Technology Futures in Edmonton, Alberta.

# BorFusion® Is Applied To:

- Electric Submersible Pumps (ESP's) and Horizontal Pumping Systems (HPS)
  - Impellers, Diffusers, Spacers, Heads, Bases, Compression Tubes, Bearing Supports, Intakes, Discharges.
- Gas Separators
  - Including All Components
- Centrifugal Pump Parts
  - Impellers, Casings & Covers
- Rod Pump Rod Guides
- Steam Injection Subs
- Profile Nipples & Stingers
  - All Sizes and Profiles
- Pup Joints
  - All Sizes
- Butterfly, Ball, Gate and Disc Valves
  - All Sizes up to 20"
- Choke Valves
  - Stems and Shafts
- Perforated Screens
- T Joints, Elbows, Crosses, Collars & Fittings
  - All Sizes
- Hex & Bull Plugs
- Swages
- Hammer Unions
- Poppet Valves
- Injector Tubes
- Jetting Nozzles
- Pressure Pistons
- Pumping Truck Gears
- Sliding Sleeves & Frac Sleeves
- Punch Dies

We are not limited to any specific functioning tool or industry; we can protect any part that is experiencing wear through Abrasion, Corrosion or Erosion.

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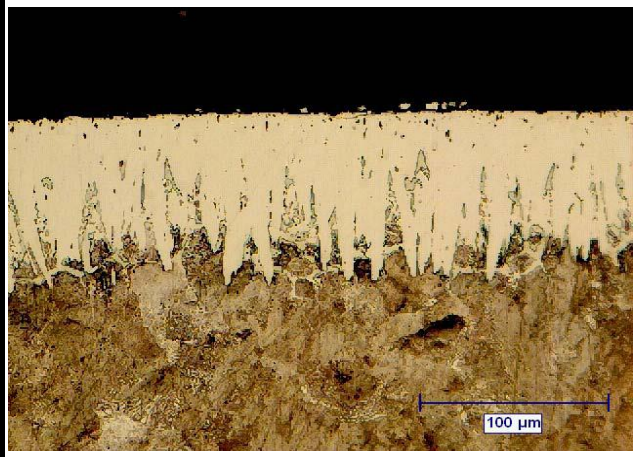
# BorFusion® Applied to Various Metals

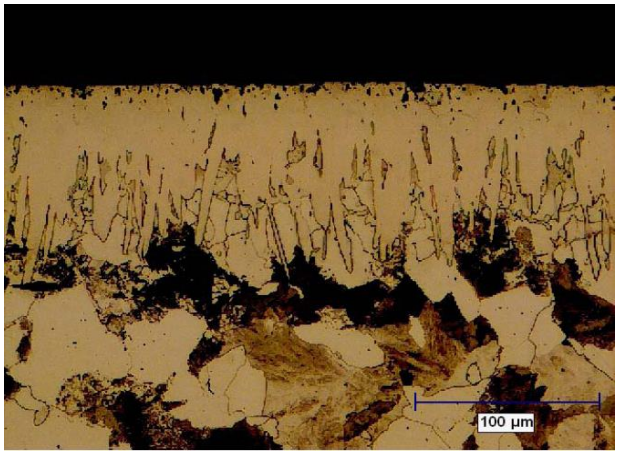
## 4140 material - ARC Report# 06-273

| Indent # | Knoop Hardness |
|---|---|
| 1 | 2073 |
| 2 | 2073 |
| 3 | 2470 |
| 4 | 1789 |
| 5 | 1602 |
| 6 | 1923 |
| 7 | 1716 |
| 8 | 1231 |
| 9 | 1339 |
| 10 | 530 |
| Base | 233 |



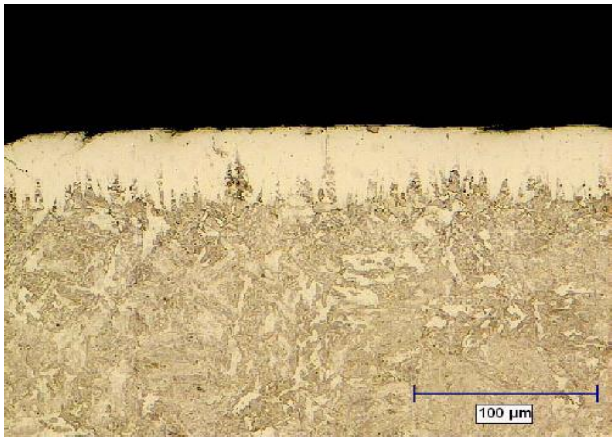

## 8620 material - ARC Report# 06-238

| Indent # | Knoop Hardness |
|---|---|
| 1 | 1692 |
| 2 | 2042 |
| 3 | 2042 |
| 4 | 1581 |
| 5 | 1520 |
| 6 | 1923 |
| 7 | 1500 |
| 8 | 936 |
| 9 | 926 |
| 10 | 1323 |
| Base | 282 |



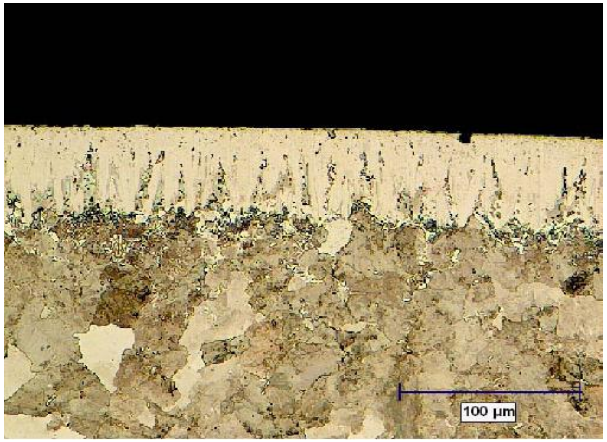

## EN30B material - ARC Report# 05-436

| Indent # | Knoop Hardness |
|---|---|
| 1 | 2351 |
| 2 | 1875 |
| 3 | 2206 |
| 4 | 1500 |
| 5 | 543 |
| 6 | 554 |
| 7 | 417 |
| Base | 457 |




## D2 Tool Steel - ARC Report# 06-106

| Indent # | Knoop Hardness |
|---|---|
| 1 | 2351 |
| 2 | 2073 |
| 3 | 1789 |
| 4 | 1895 |
| 5 | 1815 |
| 6 | 1443 |
| 7 | 417 |
| 8 | 352 |
| 9 | 308 |
| 10 | 276 |
| Base | 264 |




The Knoop microhardness testing was conducted using a 25g load. The first indent was approximately 10 micron below the surface, with subsequent indents at 0.0005" intervals, spaced within guidelines suggested by ASTM standard C1326-99.

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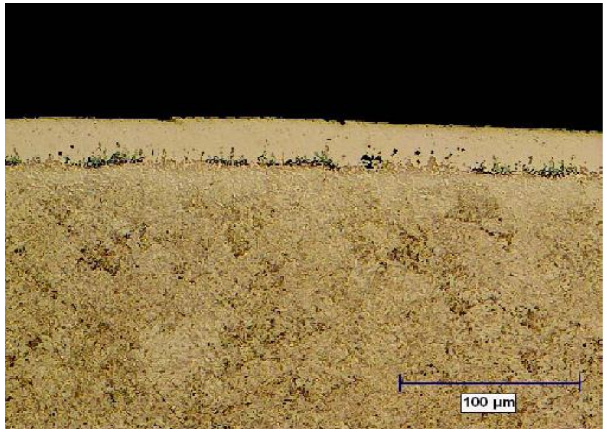
# BorFusion® Applied to Various Metals

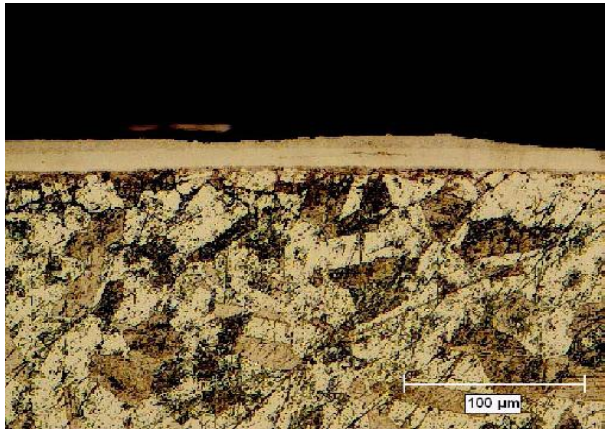
## 410 Stainless - ARC Report# 06-097

| Indent # | Knoop Hardness |
|---|---|
| 1 | 1110 |
| 2 | 1716 |
| 3 | 2073 |
| 4 | 598 |
| 5 | 341 |
| 6 | 317 |
| 7 | 271 |
| Base | 264 |



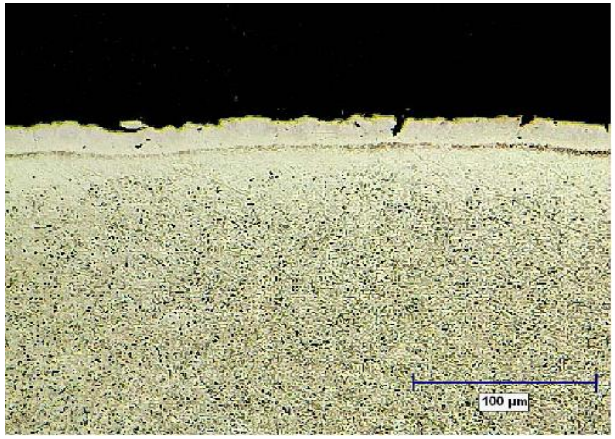

## 316 Stainless - ARC Report# 06-082

| Indent # | Knoop Hardness |
|---|---|
| 1 | 1868 |
| 2 | 917 |
| 3 | 382 |
| 4 | 311 |
| 5 | 284 |
| Base | 256 |



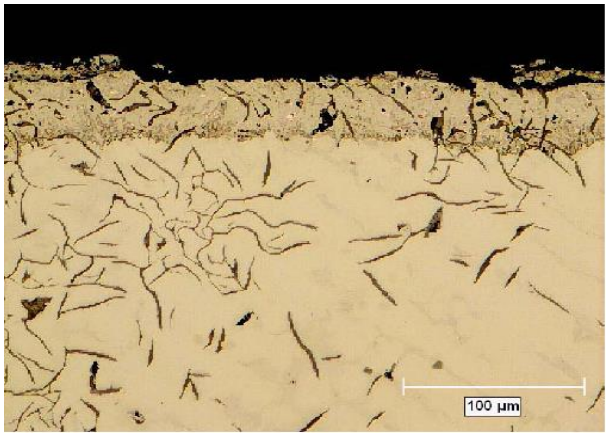

## 17-4 PH Stainless - ARC Report# 06-362

| Indent # | Knoop Hardness |
|---|---|
| 1 | 1868 |
| 2 | 917 |
| 3 | 441 |
| 4 | 398 |
| 5 | 350 |
| Base | 339 |




## Ni-Resist Cast - ARC Report# 06-082

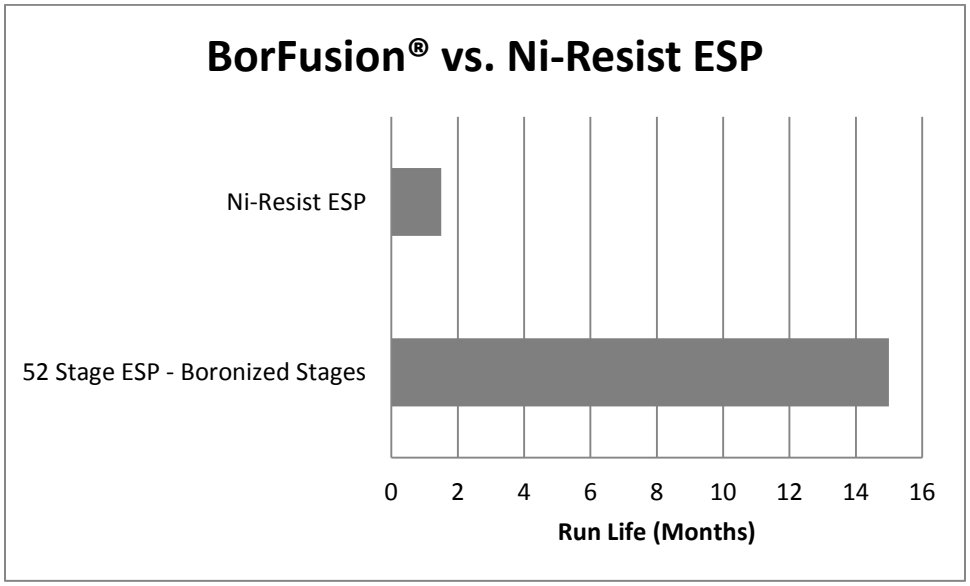
| Indent # | Knoop Hardness |
|---|---|
| 1 | 1815 |
| 2 | 955 |
| 3 | 661 |
| 4 | 451 |
| 5 | 297 |
| Base | 311 |




The Knoop microhardness testing was conducted using a 25g load. The first indent was approximately 10 micron below the surface, with subsequent indents at 0.0005" intervals, spaced within guidelines suggested by ASTM standard C1326-99.

**Well Conditions:**

- 97% water cut
- Abrasive
- Perforation depth 990m
- Three previous pulls with PC pumps before the ESP was installed

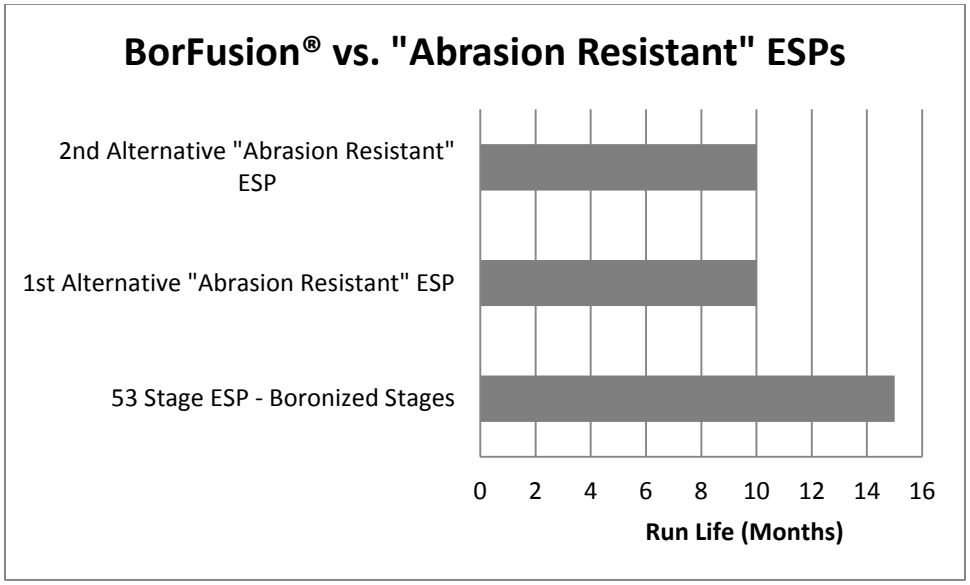



Boronizing stages with BorFusion® significantly increases ESP run life.

FOR MORE INFORMATION AND CONSULTING
Tel: 780-466-5600 • Cell: 780-224-7418 • E: sales@giantcoatings.com •
www.giantcoatings.com
*Edmonton Office: 695 – 69 Avenue NW • Edmonton • Alberta • Canada • T6P 0C2*

**Well Conditions:**

- 98% water cut
- Abrasive
- Perforation Depth 1090m
- Two previous “Abrasion Resistant” ESPs were attempted prior to Boronizing the stages
- “Abrasion Resistant” ESP’s performance deteriorated throughout run life




Boronizing stages with BorFusion® significantly increases ESP run life.


# ABRASION TEST REPORT

## Introduction

In a blind study, several materials and coatings were tested head to head in a third-party lab, Alberta Research Council (now known as; Alberta Innovates Technology Futures). Standardized testing was conducted to determine which material obtained for hardness values and which coating showed greater abrasion resistant characteristics. The ASTM G65 abrasion test was chosen to best reflect the desired results - this test demonstrates a material's ability to resist abrasion due to dry sand. Boronizing was one of the coatings mixed into the blind study, which is a process carried out by Giant Coatings in Calgary known as their **BorFusion®** procedure.

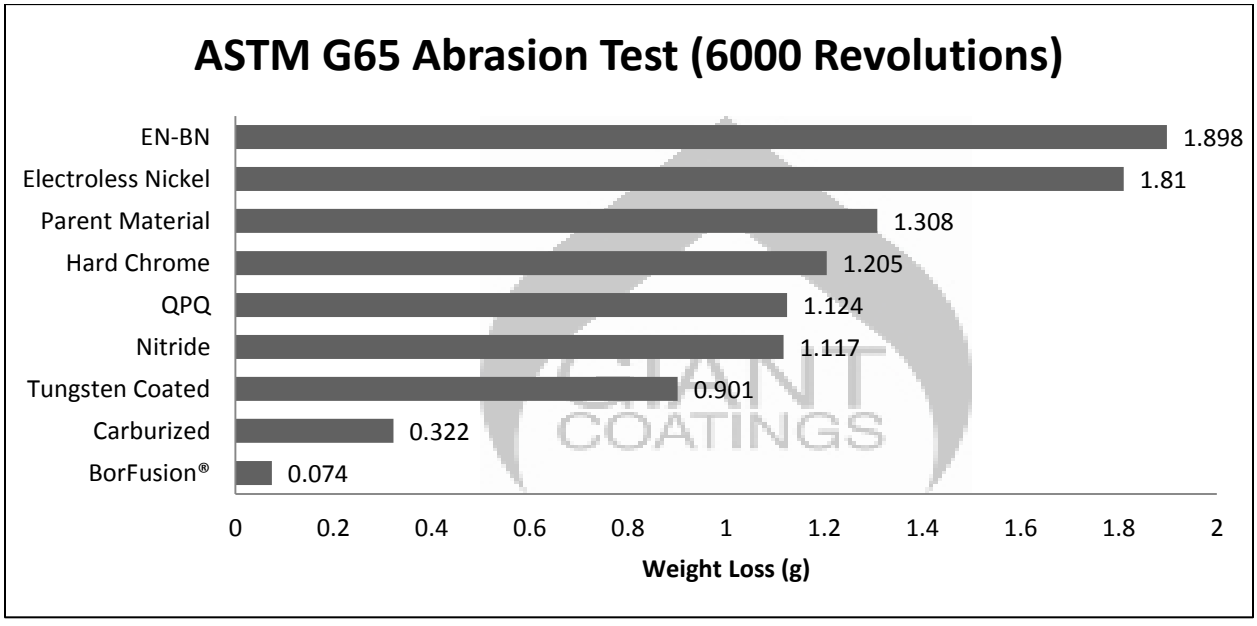
## Conclusion

The blind tests showed that boronizing (also known as boriding or **BorFusion®**) was clearly the hardest surface material and most abrasion resistant off all the coatings and materials tested.

## Results

The tables below represent the measured performance of the selected materials and coatings. Boriding (**BorFusion®**) not only provided the hardest surface, but also the most abrasion resistant product. To test hardness on thin coatings & surface finishes, micro-hardness testing on the Knoop scale must be used - the Knoop scale can be converted into Rockwell C values. The results indicate that boronized (**BorFusion®**) 4140 steel showed a surface hardness of 2000 HK (which converts to over 80 Rockwell C) and its material loss in the abrasion test is over 4x better than the next best treatment and over 17.5x better than the un-treated parent material!

## A. Abrasion Resistance



## B. Hardness

| Coating | Thickness | Advertised Hardness (HRC) | Actual Knoop Hardness (HK) | Converted Rockwell Hardness (HRC) |
|---|---|---|---|---|
| **BorFusion®** (diffusion) | 0.004" | 76 to 80+ | 2000 | over 80 |
| Carburized (diffusion) | undetermined | 50 to 65 | 629 | 57 |
| Tungsten Coating (Chemical vapour) | 0.002 | 69 - 80+ | 1507 | 75 |
| Nitride (diffusion) | 0.001" | 55 to 69 | n/a | n/a |
| QPQ (diffusion) | 0.001" | 55 to 69 | 455 | 46 |
| Hard Chrome (plating) | 0.003" | 59 to 69 | 850 | 66 |
| Parent Material (no coating) | None | 22 | 246 | 22 |
| Electroless Nickel (plating) | 0.001" | 60 to 70 | 511 | 50 |
| EN-BN (plating) | 0.002" | 60 to 63 | 502 | 49 |

## Coating Descriptions

These coatings have been advertised for their abrasion, erosion and/or corrosion protection properties and have therefore been selected for testing purposes. Brief descriptions of the coatings or materials listed above are indicated here.

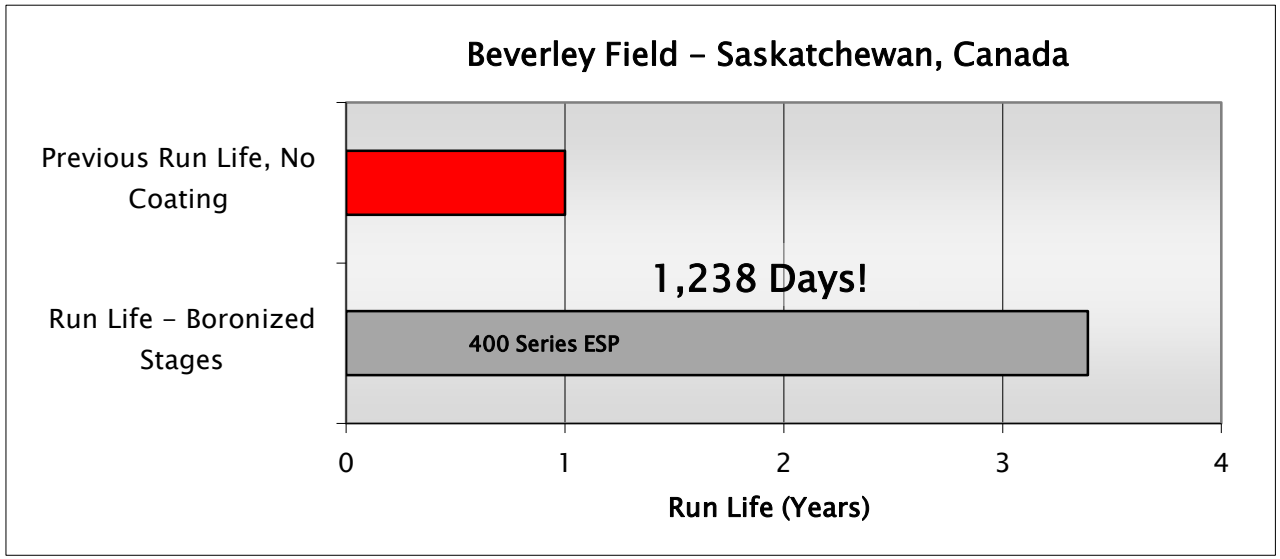
1. **BorFusion® -** Diffusion chemical reaction (pack) where boron molecules are diffused into the substrate of the part. Key Benefits: Abrasion, Erosion & Corrosion resistant properties, hardness range of 75 - 80+ HRC
2. **Carburized -** Diffusion method (Gas) where carbon is diffused into the substrate of the material. Key Benefits: Abrasion resistant properties, hardness range of 50 - 60 HRC
3. **Tungsten Coating -** Chemical Vapor method where Tungsten Carbide is deposited onto the surface of the material. Key Benefits: Abrasion & Corrosion resistant properties, hardness range of 69 - 80 HRC
4. **Nitride -** Diffusion (Gas) method where Nitrogen molecules are diffused into the material substrate. Key Benefits: Abrasion resistant properties, hardness range of 55 - 69 HRC
5. **QPQ Liquid Nitride -** Diffusion (Liquid) method where Nitrogen molecules are diffused into the substrate of the material. Key Benefits: Abrasion & Corrosion resistant properties, hardness range of 55 - 69 HRC
6. **Hard Chrome -** Electrolytic plating method where Chromium is deposited onto the surface of the material. Key Benefits: Abrasion & Corrosion resistant properties, hardness range of 59 - 69 HRC
7. **Parent Material -** 4140 alloy steel in L80 grade with no protective coating applied. Hardness of 22 HRC

8. **Electroless Nickel -** Autocatalytic plating (Mid Phos.) method where Nickel is deposited onto the surface of the material. Key Benefits: Corrosion resistant properties, slight Abrasion resistant properties, hardness range of 60 - 70 HRC
9. **EN-BN -** Autocatalytic plating method where Nickel and Boron Nitride are deposited onto the surface of the material. Key Benefits: Corrosion resistant properties, increased abrasion resistant properties, hardness range of 60 - 63 HRC

## Discussion

Comparing metallic coatings provides significant challenges when different coating techniques are used such as the chemical vapour deposition, electrolytic plating, autocatalytic plating, and diffusion process which were all used in this study. Each process is effective in its own right; however the thickness of each coating can differ significantly as well the underlying substrate properties may also be altered due to the process. The diffusion method coatings require higher heat to diffuse or impregnate the specific compounds into the substrate material, whereas the plating methods utilize lower heat. The major difference is that the diffusion coating process bonds chemically to the part, creating a new surface layer material, whereas the plating processes deposit the coating onto the surface of the parent material.

Last Well Update was on August 29, 2009.




In the Beverley Oil Field area, typical run life of an ESP is up to one year. At which point there is significant wear due to abrasion on the ESP Impellers and Diffusers, causing them to be replaced.

**BorFusion®** is proven to extend the run life of ESP's due to its extremely high resistance to Abrasion, Corrosion and Erosion. In this particular testimonial, **BorFusion®** has outlasted the previously installed un-coated pump by nearly 3 1/2 years!

Take a moment to consider the return on investment with ZERO pump replacements for nearly 3 1/2 years!

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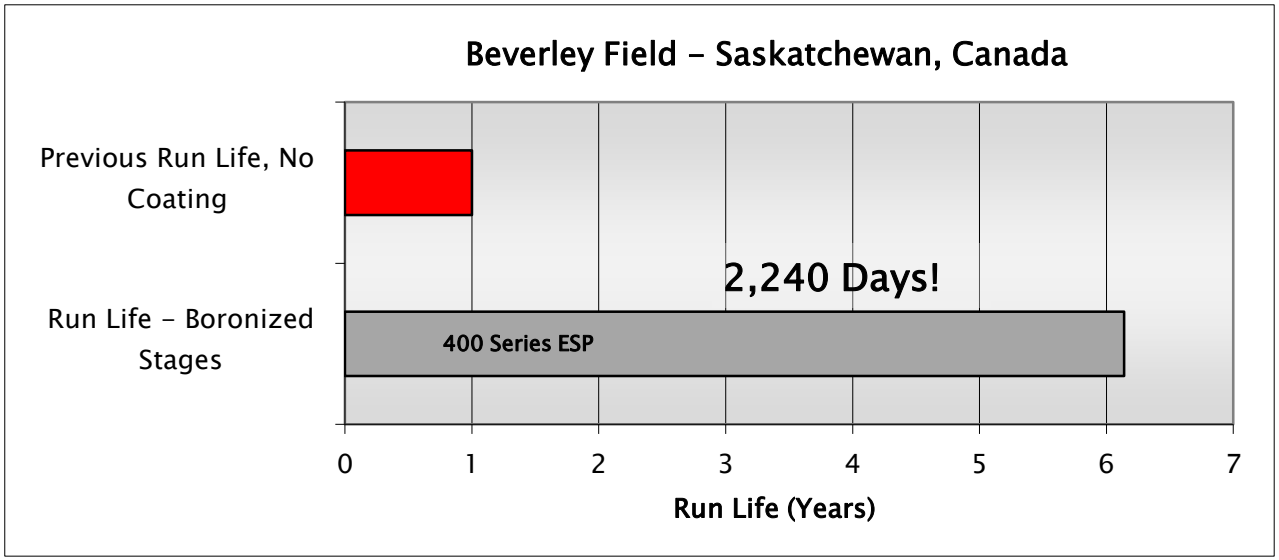


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Take a moment to consider the return on investment with ZERO pump replacements for over 6 years!

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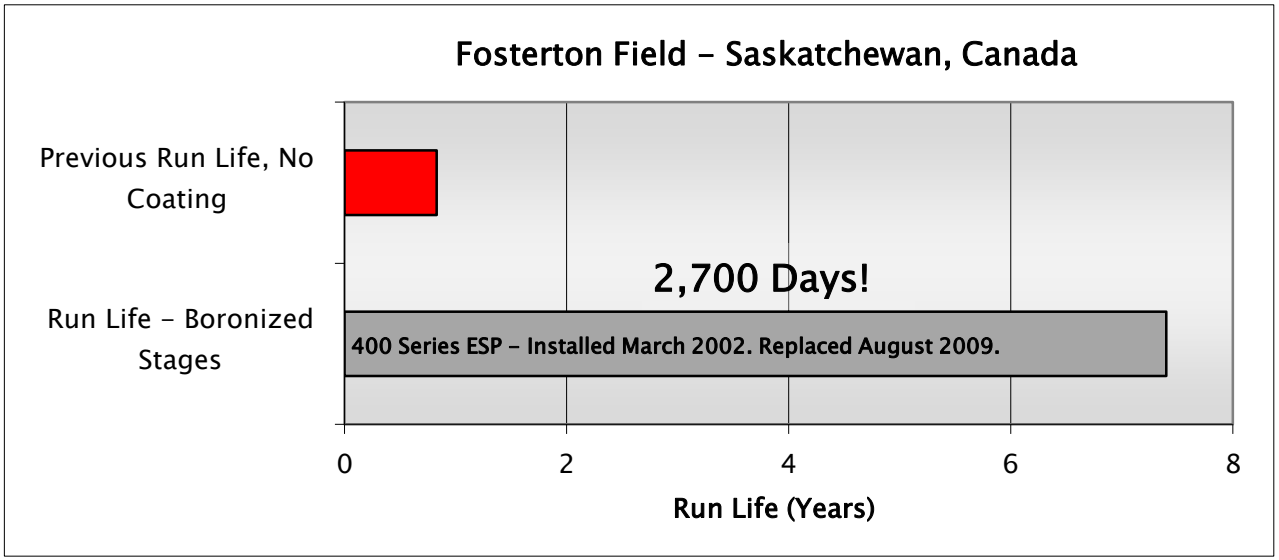
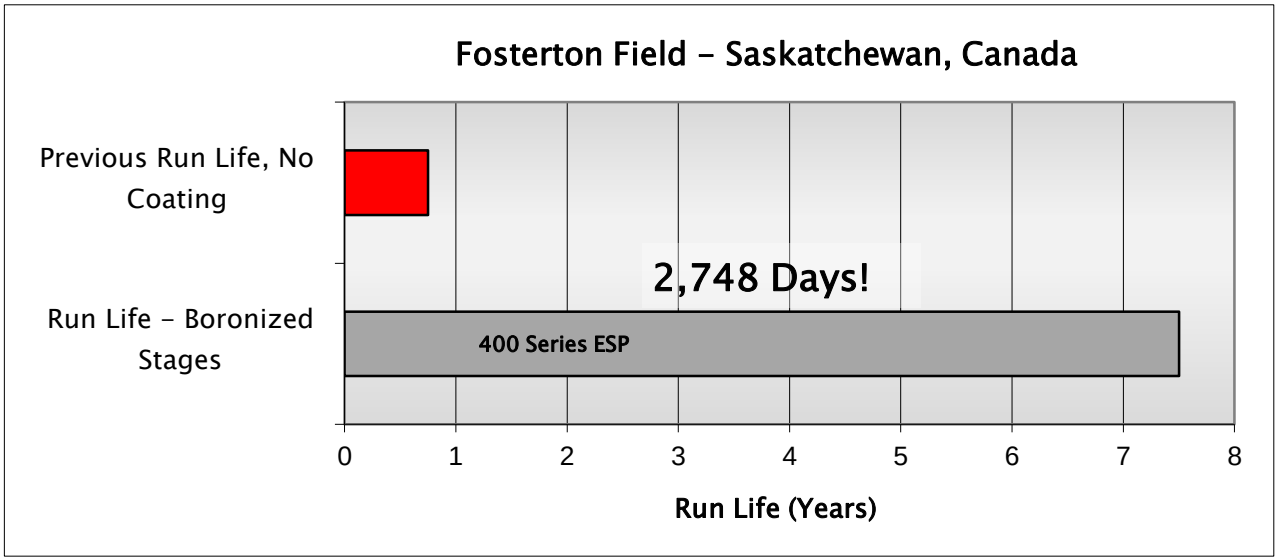



In the Fosterton area, typical run life of an ESP is up to one year. At which point there is significant wear due to abrasion on the ESP Impellers and Diffusers, causing them to be replaced.

**BorFusion®** is proven to extend the run life of ESP's due to its extremely high resistance to Abrasion, Corrosion and Erosion. In this particular testimonial, **BorFusion®** has outlasted the previously installed un-coated pump by nearly 6 1/2 years!

Take a moment to consider the return on investment with ZERO pump replacements for nearly 7 1/2 years!

Last Well Update was on August 29, 2009.

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