

Ultimate Surface Performance

OIL & GAS APPLICATIONS

INNOVATIVE SURFACE TREATMENTS & COATINGS

- Liquid / Salt Bath Nitriding
- PVD/DLC Coatings



www.hefusa.net
sales@hefusa.net
(937) 323-2556

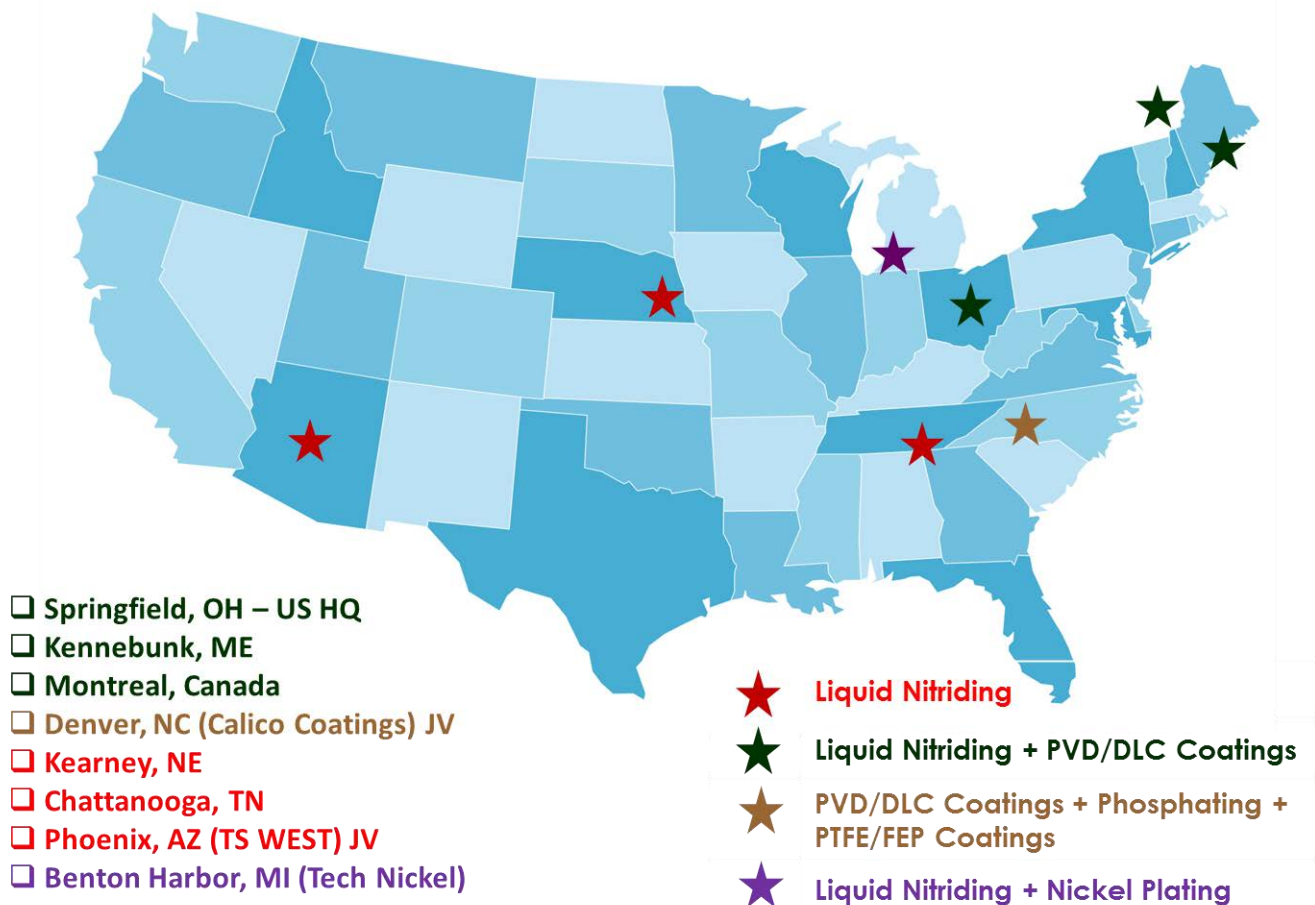


HEF GROUP OVERVIEW

- HEF Group through its global network of 60+ jobbing facilities in 20 countries, is one of the world's largest suppliers of wear, friction and corrosion reduction treatments and coatings for precision components utilized for a diverse range of industries, including Automotive; Oil & Gas; Hydraulic and Pneumatic equipment; Industrial machinery etc.
- HEF Group is the only global supplier of both **Liquid Nitriding treatments** and **PVD/DLC coatings** for engineered Oil & Gas components.
- HEF in the US also provides other surface engineering options that are prevalent within the Oil & Gas industry. These treatments include **Electroless Nickel Plating; Manganese Phosphate and PTFE/FEP/PFA Coatings**.



JOBGING FOOTPRINT US & Canada



Liquid Nitriding (LN) / Salt Bath Nitriding (SBN) / Nitrocarburizing

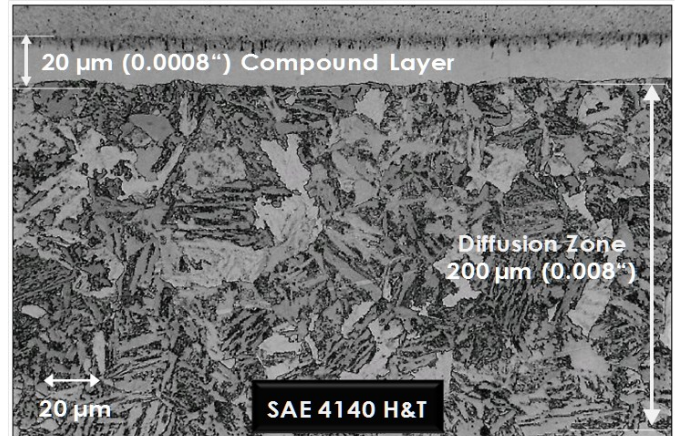
Liquid Nitriding is a thermo-chemical **diffusion** treatment that enriches the surface of steels and cast iron with Nitrogen.

The surface **Compound Layer** is composed of iron nitrides + special nitrides. The area below the compound layer, is the **Diffusion zone** where Nitrogen diffuses into the iron lattice to form a solid solution.

HEF Group's trademarked family of Liquid Nitriding processes:

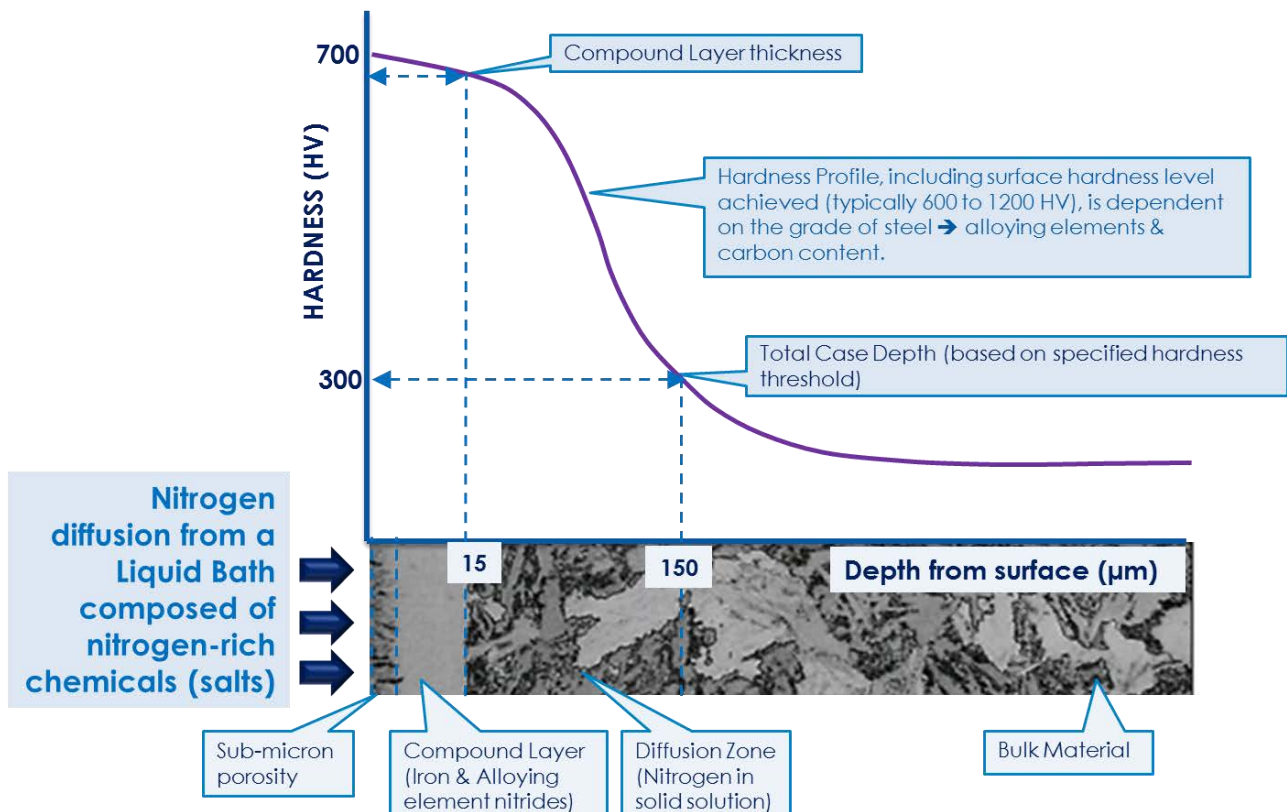
ARCOR® : ARCOR V, ARCOR C, ARCOR N, ARCOR DT, SURSULF®,...

MELONITE® : TF1, QP, QPQ, TENIFER®, TUFFTRIDE®,...



LIQUID NITRIDING BENEFITS

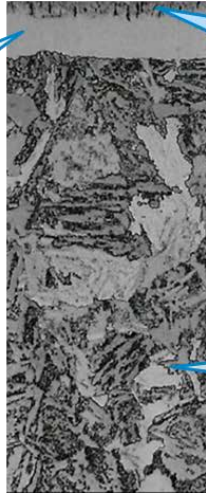
- Hard (600-1200 HV) surface layer provides very good wear resistance
- Good frictional properties
- Excellent scuffing / seizure protection (adhesive wear)
- Excellent corrosion protection
- Good surface fatigue resistance
- Decorative black surface



ARCOR® LIQUID NITRIDING

COMPOUND LAYER:

- Very high hardness
 - Abrasion wear resistance
 - Adhesive wear / Scuffing resistance
- Low-friction



OXIDE LAYER:

- Corrosion Resistance
- Impregnate micro-porosity
 - Low-friction, running-in Layer
- Black finish

DIFFUSION ZONE:

- Fatigue Strength
- High Compressive Strength
- Hardness higher than bulk

QPQ Process—well established for Oil & Gas applications

Q

• Nitriding (Q): Standard nitriding, followed by oxidation

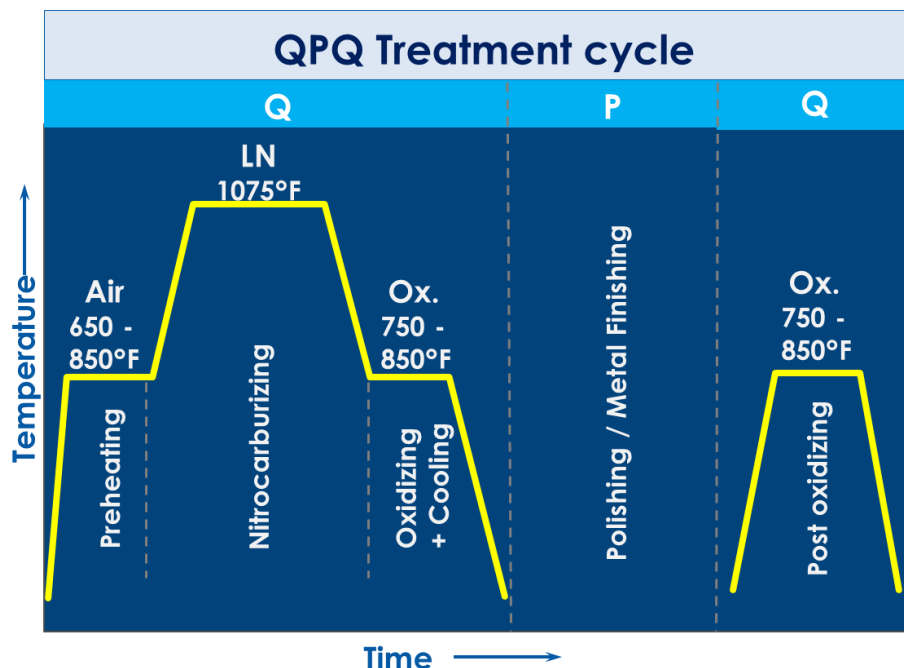
P

• Polishing / Metal Finishing (P): To reduce post-nitriding surface roughness

Q

• Re-Oxidation (Q): To recover the oxide layer removed during the Polishing / Metal Finishing Step after Nitriding

This Re-oxidation can be replaced by an **IMPREGNATION** step - whereby the surface sub-micron porosity is impregnated with HEF proprietary, especially formulated oils & polymers, which significantly im-



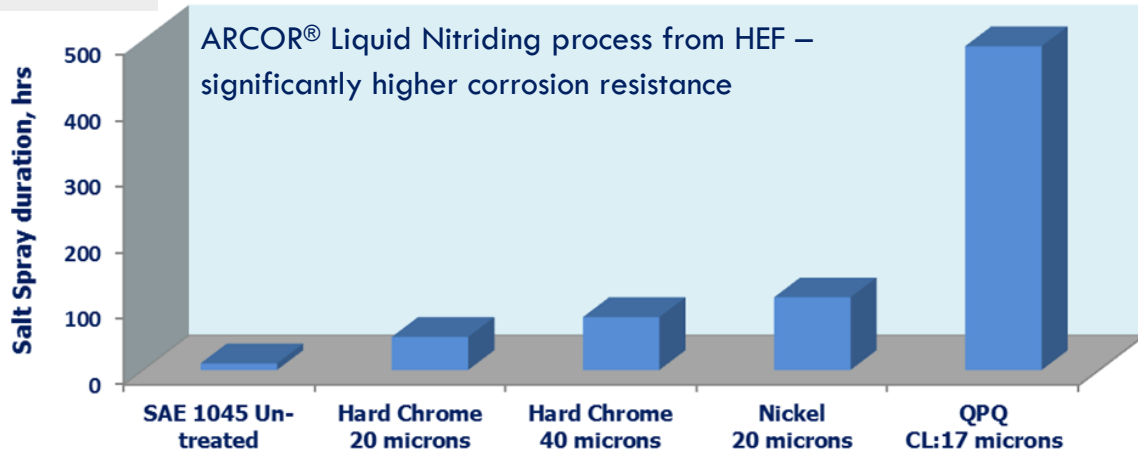
Polishing / Metal Finishing: To reduce post-nitriding surface roughness

Post Oxidation: To recover the oxide layer removed during the Polishing / Metal Finishing Step after Nitriding

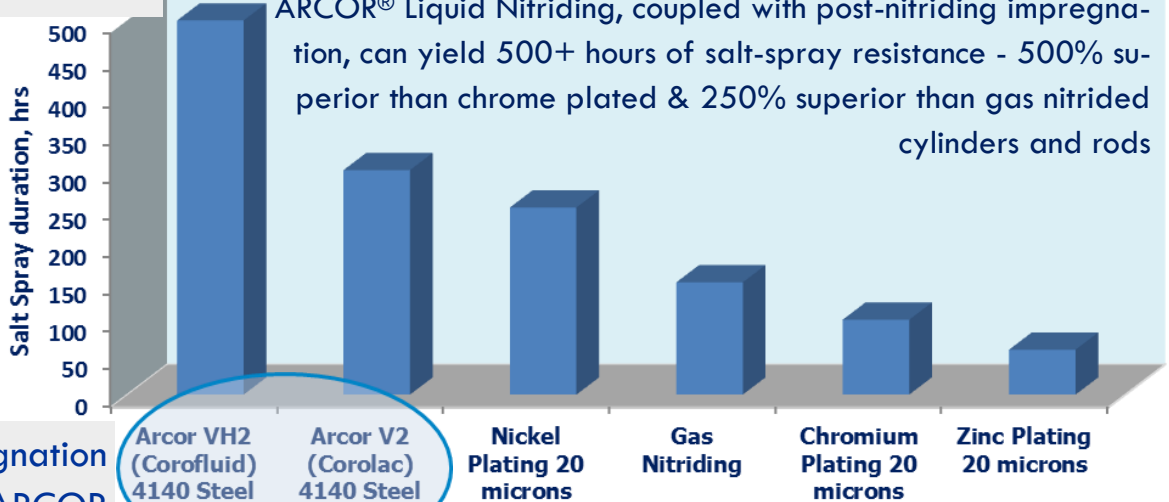
ARCOR® LIQUID NITRIDING: PROPERTIES

CORROSION RESISTANCE

1045 Steel



4140 Steel



Impregnation after ARCOR process

NOTE: Salt Spray tests are suitable only for comparative and relative evaluation of corrosion resistance. The salt spray hours

achieved are a function of several factors, including: steel grade; geometry of the part being tested; and surface treatment/coating.

SALT SPRAY Per ASTM B117
CORROSION TESTING RESULTS

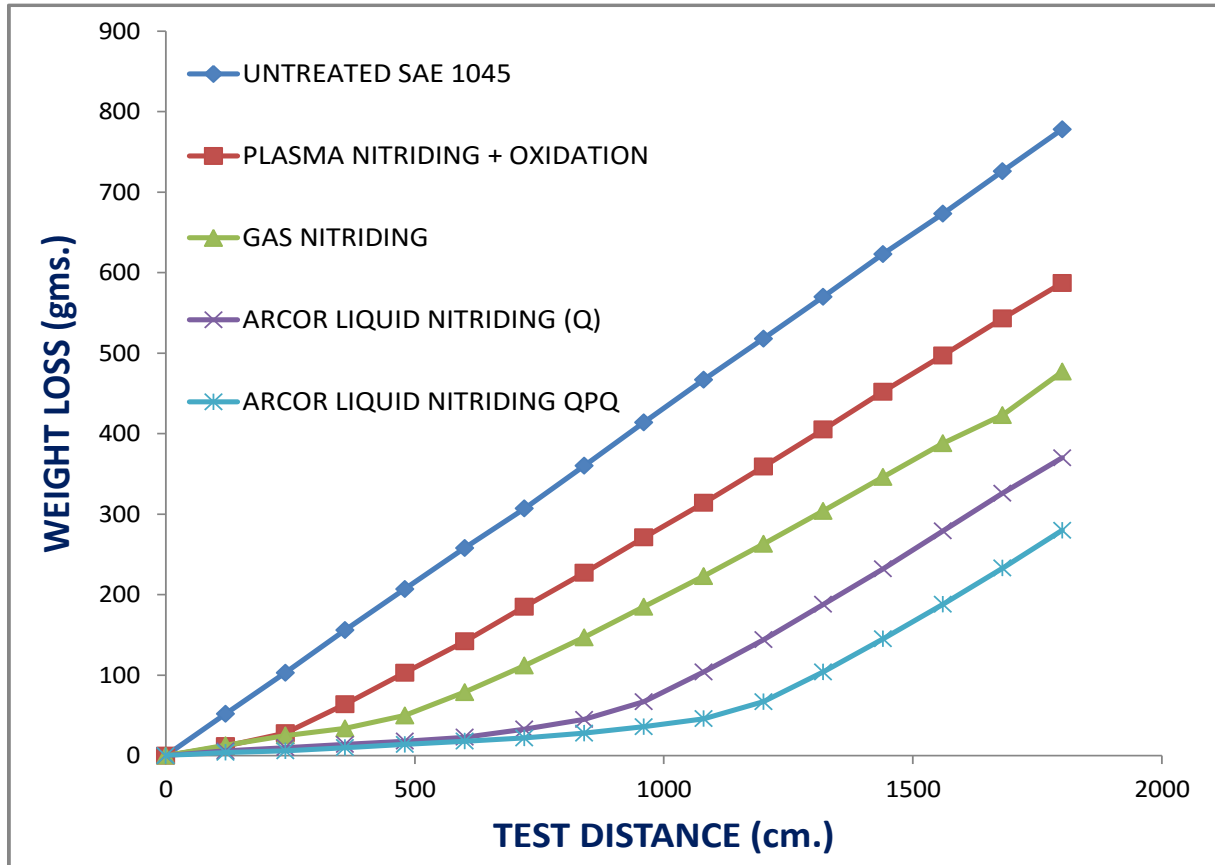
CHROME



ARCOR LIQUID NITRIDE + Impregnation

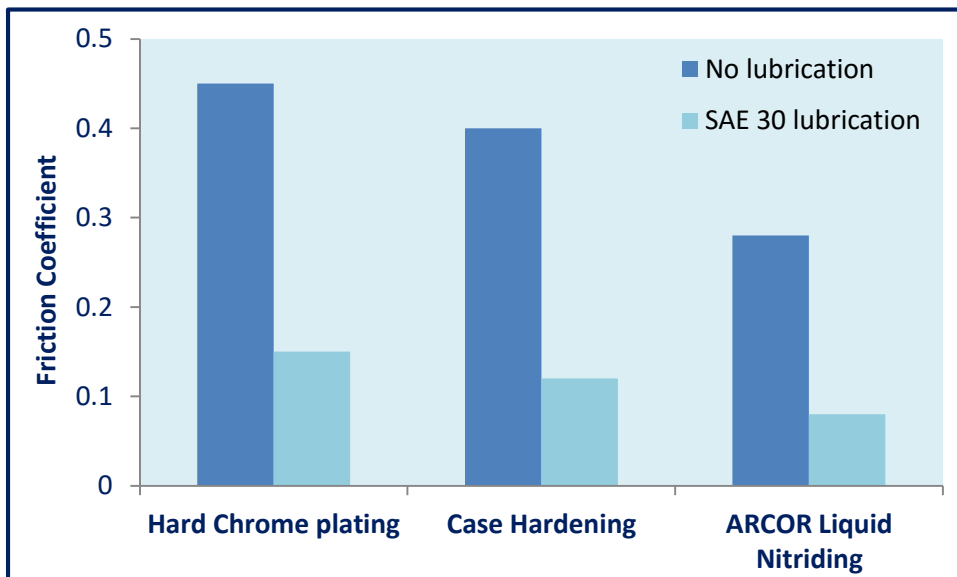
ARCOR® LIQUID NITRIDING: PROPERTIES

WEAR RESISTANCE



ARCOR® Liquid Nitriding from HEF – superior wear-resistance compared to gas & plasma nitriding options and several fold higher than un-treated steels

FRICITION



ARCOR® Liquid Nitriding process from HEF – lower friction coefficient

ARCOR® LIQUID NITRIDING: APPLICATIONS

MISCELLANEOUS O&G COMPONENTS

Fracking

- ◆ Fluid-end Blocks
- ◆ Misc. hydraulic system components

Well-head

- ◆ Valve chokes
- ◆ Blowout preventer components
- ◆ Gate valve components

Drilling

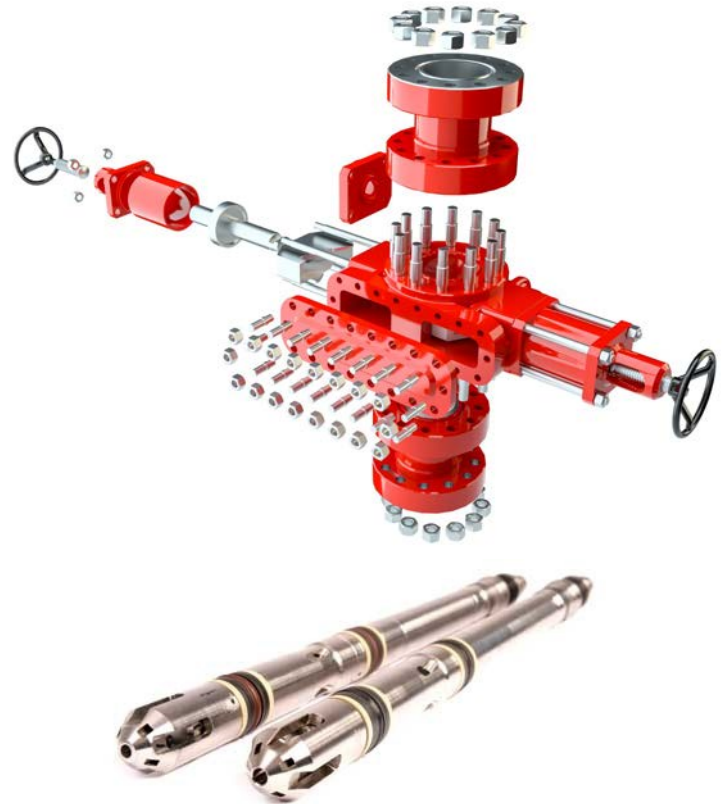
- ◆ Downhole drilling rotors
- ◆ Bearing sleeves
- ◆ Flow diverters

Downhole & Completion Tools

- ◆ Stems, Piston Rods, Plungers, Mandrels & Connector pins
- ◆ Collets, Sleeves & Couplings
- ◆ Wash pipes
- ◆ Impellers & Diffusers for artificial lift pumps

Hydraulic cylinders: Excellent chrome & nickel plating replacement option:

- ◆ 5x higher corrosion resistance
- ◆ No surface peeling nor flaking
- ◆ Lower friction due to post-nitriding impregnation of the surface micro-porosity
- ◆ Good impact & bend resistance thanks to the ductile surface
- ◆ Competitive pricing



BENEFITS OF ARCOR® LIQUID NITRIDING

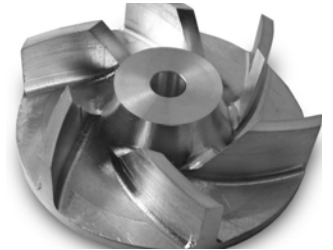
- Minimizes adhesive, abrasive and erosive wear
- Reduced galling & scuffing
- Reduced friction
- Significant corrosion reduction

PUMP COMPONENTS

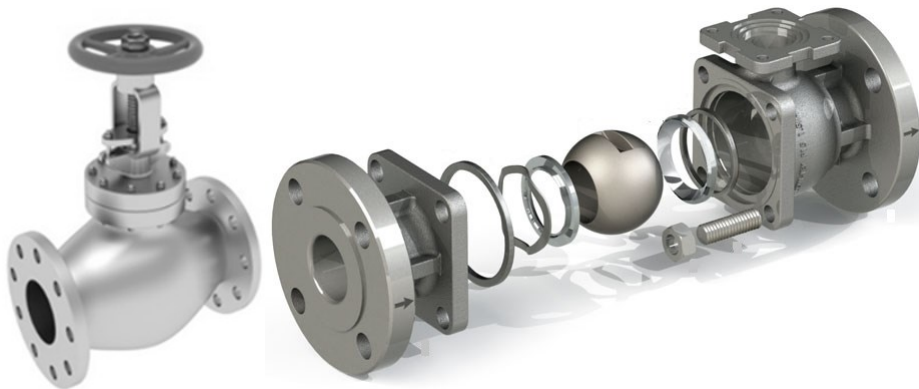


- ◆ Significant corrosion reduction
- ◆ Reduced wear
- ◆ Ability to effectively treat cast-iron and stainless-steel pump components.
- ◆ Treatment ideally suited for high pressure applications; handling corrosive and erosive media

- Housing
- Swash plates
- Impellers
- Pistons
- Screws
- Misc. Components



VALVE COMPONENTS



- ◆ Reduced wear of sliding components
- ◆ Significant corrosion reduction
- ◆ Lower friction forces

- Ball/Plug
- Stem
- Stem seal
- Glands
- Thrust Washers
- Stem Bushing (upper & lower)
- Metal seat
- Drive Shaft
- Downstream & Upstream seat



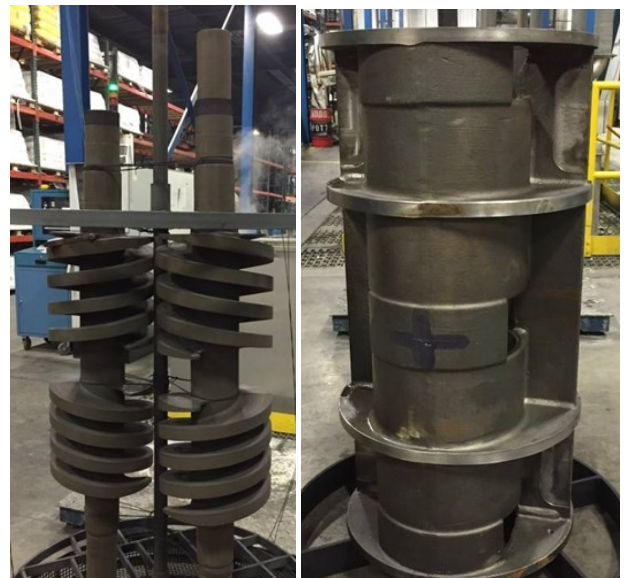
OIL & GAS COMPONENTS

ARCOR[®] LIQUID NITRIDING FACILITY



STATE-OF-THE-ART LIQUID NITRIDING LINE: CHATTANOOGA, TN

- ◆ Largest Operating equipment in North America. Part size capability:
 - **Maximum Length: 8 feet (2.5 m). With flipping: 15 feet (4.5 m)**
 - **Weight: 4,000 lbs. (1,800 kg.).** Heavier - with special arrangements
- ◆ Fully instrumented, computer controlled and capable of remote monitoring. Batch-to-batch traceability and process recording.
- ◆ An in-line, post-nitriding impregnation process can provide an added level of corrosion protection and surface lubricity to the nitrided components.
- ◆ The facility is equipped with a variety of post-nitriding surface finishing processes to ensure a customer and application specific surface finish can be achieved after nitrid-



Screw Pump: 60" high

OIL & GAS COMPONENTS

ARCOR® LIQUID NITRIDING FACILITY

NORTH AMERICA'S LARGEST LIQUID NITRIDING LINE: CHATTANOOGA, TN

- ◆ Ability to treat materials widely utilized for Oil & Gas equipment components:
 - Carbon & Alloy Steels: 4145H, 4140, 4330, 8630....
 - Martensitic Stainless Steels: 13Cr, 410, 420....
 - Austenitic Stainless Steels: 316, 304, 321, 317L.....
 - PH Stainless Steel grades: 17-4, 15-5
 - Nickel Alloys: Inconel 718
- ◆ Facility specifically designed for Liquid Nitriding of heavy & large size Oil & Gas valve, wellhead, drilling, fracking, downhole and logging components



15 feet long Inconel tubes



Fracking Block
4000 lbs.



Tubes for polymer
powder transport



12 feet long, 2000 lb.
accumulator tubes

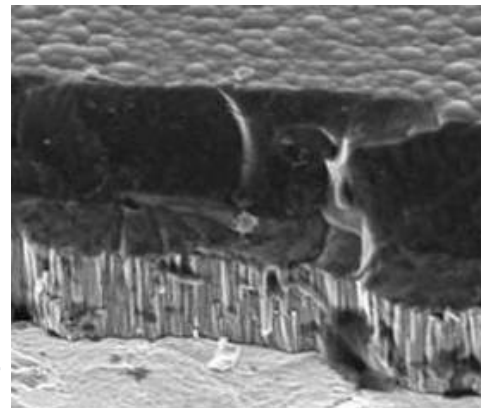
PVD / Diamond-like-Carbon (DLC) Coatings

While Liquid Nitriding is a surface modification technology, Physical Vapor Deposition (PVD) involves the deposition of very hard, thin (2-4 microns; 0.0001”- 0.0002”) films on the surface of components.

The PVD process, conducted under high vacuum conditions, involves the extraction of material, in atomic or ionic form, from a high-purity solid source, such as Titanium, Chromium etc. This extraction is done by bombarding the source material with high-energy inert gas ions. The extracted ions/atoms react with gases such as nitrogen to form thin and very hard coatings such as Titanium and Chromium nitride. If a source material, such as a hydrocarbon gas, is utilized - a very hard, ultra low-friction **Diamond-like-Carbon (DLC)** coating can be deposited.

BENEFITS OF DLC COATINGS

- Very hard (1500-3000 HV): High resistance to wear, abrasion and erosion.
- Thin (2 to 5 microns) coatings - does not impact component tolerance
- Very low friction coefficients (0.1 -0.15) . This translates into lower wear rates, lower power losses and higher efficiency.
- Low coating temperatures (150-200°C) - no component distortion or loss of core hardness
- Higher load carrying capacity with fewer lubricant additions, and less erosion.



Electroless Nickel Plating

Electroless Nickel platings have been used for several decades to enhance the wear and corrosion resistance of Oil & Gas components. HEF's Benton Harbor, Michigan location can mid-Phosphorus Nickel plate parts that are 9 ft. long and weigh as much as 4,000 lbs. each.

Manganese Phosphate Coatings

Black Manganese Phosphate, also known as Parkerizing, is a process that reduces friction and resists corrosion. Phosphate produces a fine, dense crystalline coating on ferrous metal substrates. This reduces wear, and facilitates break-in of surfaces; it can be applied to virtually any ferrous metal component. It is especially effective in reducing running-in wear of sliding parts, galling and scoring.

HEF's CALICO JV facility in Denver, NC provides Manganese Phosphate coatings.

HEF GROUP: GLOBAL SUPPLIER OF A DIVERSE RANGE OF SURFACE TREATMENT TECHNOLOGIES FOR THE OIL & GAS INDUSTRY

- Liquid / Salt Bath Nitriding / QPQ
- PVD/DLC Coatings
- Miscellaneous other treatments/coatings:
 - ◆ Electroless Nickel Plating
 - ◆ Manganese Phosphate coating
 - ◆ PTFE/FEP/PFA Coatings



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