Ultimate Surface Performance

FIREARM APPLICATIONS

HEF GROUPE

INNOVATIVE

SURFACE TREATMENTS & COATINGS

- Liquid / Salt Bath Nitriding
- PVD Coatings
- DLC Coatings
- Phosphating
- REM Superfinishing
- Electroless Nickel Plating

Full Line of Advanced Surface Treatments

HEF Group, through its several US & Canada locations, offers the Firearms industry a complete range of advanced surface treatments and coatings to enhance performance and durability.

With our wide selection of advanced surface finishes, firearms manufacturers can select the surface treatment that best meets the performance needs and requirements of their specific firearm. Using HEF's diverse treatments and coatings can significantly improve your firearms wear, corrosion and erosion resistance; sliding friction, scuffing resistance and overall cosmetic appeal.

HEF offerings for Firearm applications include the following:

- **MELONITE® and ARCOR® QPQ / Salt Bath Nitriding**
- **Physical Vapor Deposition (PVD) Coatings**
- **Diamond-like-Carbon (DLC) Coatings**
- **REM Super-finishing**
- **Manganese Phosphating**
- **Electroless Nickel Plating**

HEF Group, through its various facilities in the US and Canada, is the largest and most diverse provider of innovative surface treatments, coatings and finishes to the Firearms industry. Our facilities are located in all key geographic regions of the US where firearms manufacturing is prevalent. Our extensive experience and expertise with not only firearms, but also precision engineered mechanical components, makes us an excellent partner to customize our surface engineering technology to the customer's specific needs and requirements. Our engineering strengths, along with operational responsiveness and competitive pricing, makes HEF an excellent choice to be the Firearm industries comprehensive supplier for a diverse range pf performance enhancing surface treatments and coatings.

MELONITE® & ARCOR® Liquid Nitriding

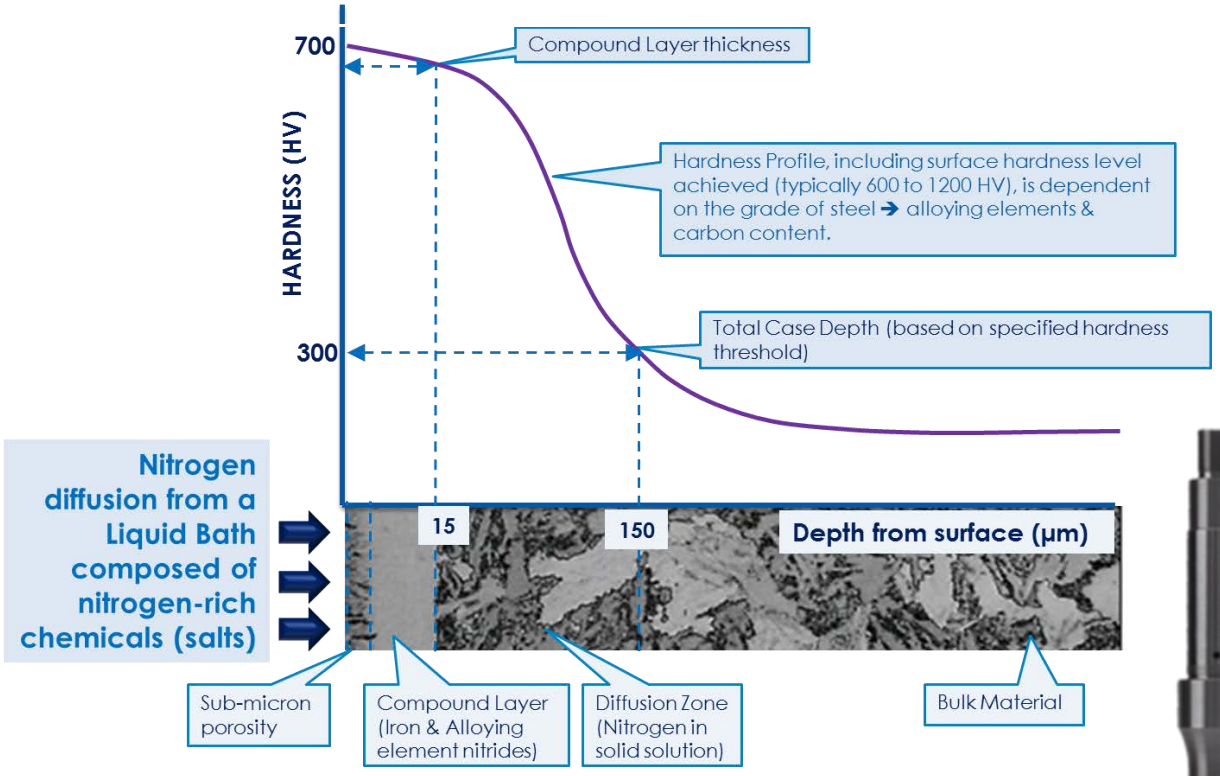
Liquid Nitriding is a thermo-chemical **diffusion** treatment that enriches the surface of steels and cast iron with Nitrogen.

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®,…

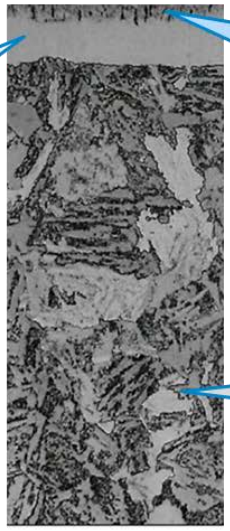
MELONITE® : TF1, QP, QPQ, TENIFER®, TUFFTRIDE®,...



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**

MELONITE® & 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 FIREARM 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 improve corrosion protection & run-in characteristics

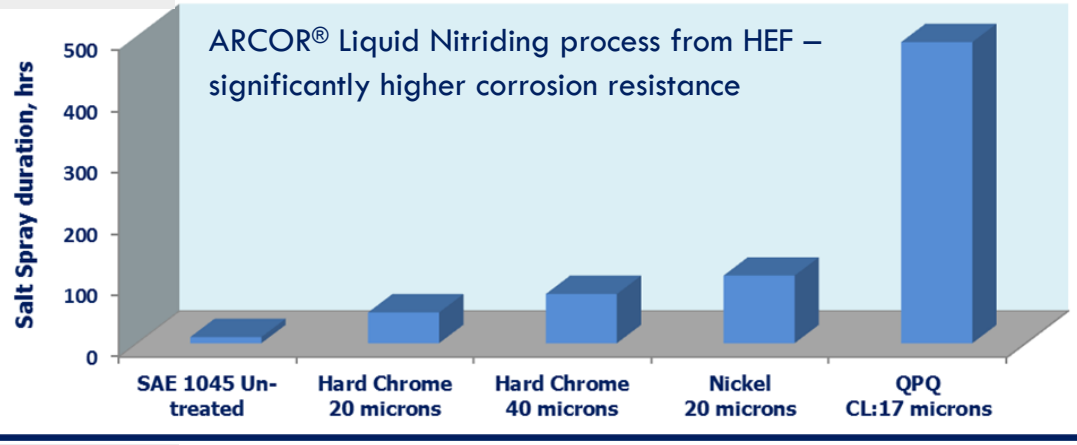
Careful control of our nitriding bath chemistry ensures that our customers that are receiving the highest quality case-hardened layers available and the product they receive is consistent and uniform each and every time it is processed. Whether you have developed your own specification or follow AMS 2753C specification, HEF can meet your requirements. HEF has diverse pre and post-nitriding finishing capabilities as well. We can also polish the ID of nitrided barrels. Whether you require a matte finish, satin finish or a polished finish, HEF has the equipment and a process that can meet your needs.

Handgun slides, barrels, frames and many of the small parts such as sights, safeties, slide release and mag catches are Salt Bath Nitrided to improve corrosion and wear.

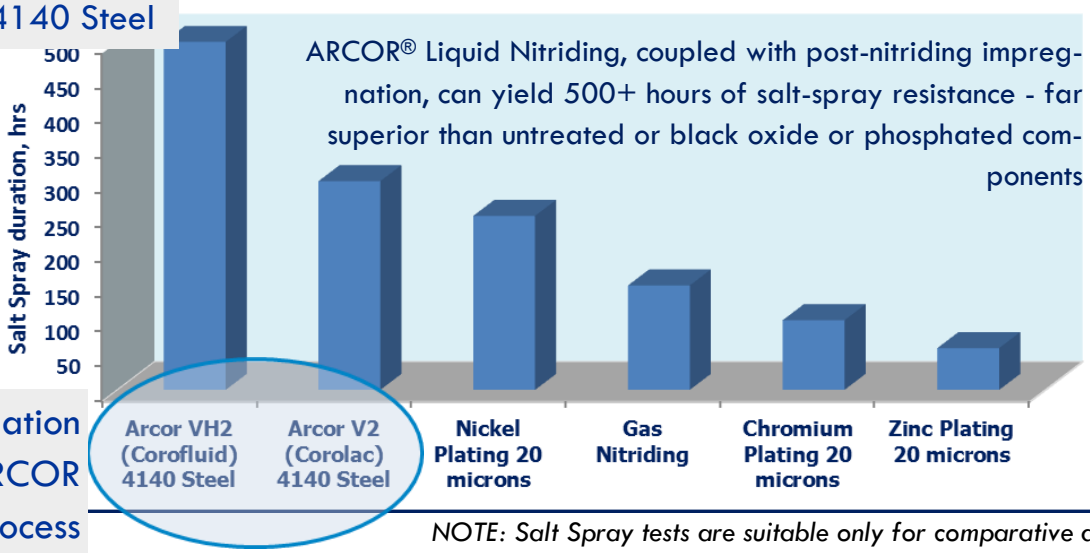
MELONITE® & ARCOR® Liquid Nitriding

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.

PVD Coatings Overview

Physical Vapor Deposition (PVD) coating involves the deposition of thin (2-10 microns; 0.0001"- 0.0004") films on the surface of components. The PVD coating process, conducted under high vacuum conditions, can be divided into three stages:

- **Evaporation** - Removal of material from the target, source or cathode. Material is usually extracted from a high-purity solid source, such as Titanium, Chromium etc., by sputtering or by an arc-discharge.
- **Transportation** - Travel of evaporated material from the source to the surface of the component to be coated. The transportation step is through a plasma medium. Plasma is a collection of charged particles (ions), whose constituents can be influenced by magnetic fields and tend to travel in straight lines or "line of sight" from source to substrate. Different characteristics are imparted to the plasma depending upon the technique used to generate it.
- **Condensation** - Nucleation and growth of the coating on the component surface. A PVD coating is formed when plasma constituents and reactive gases, such as nitrogen, combine on the component surface to form thin and very hard coatings such as Titanium nitride (TiN) and Chromium nitride (CrN).

Besides its specific chemical constituents and the architecture of the sub-layers, the properties of a PVD coating depend upon: ion energy; the degree of ionization of the metal ions; and mobility of the atoms condensing on the component surface. If instead of a solid source, a hydrocarbon gas is utilized as the source material - a very hard, ultra low-friction Diamond-like-Carbon (DLC) coating can be deposited. This gas based process is referred to as **PACVD - Plasma Assisted Chemical Vapor Deposition.**

Attributes of PVD Coatings		
Hardest (1500 – 4500 HV) known synthetic materials	**Thin (2 to 5 microns)** coatings – minimal impact on size tolerance	**Low coating temperature (150 – 250° C)** – no distortion or core hardness loss
Low friction coefficients (0.1 – 0.5) – minimize friction losses	**Line of sight process** – difficult to coat cavities or IDs	**High Adhesion to a wide range** steels, copper-alloys, plastics, glass……
Ability of deposit **alloyed and multilayered coatings**	**Possible to mask regions** on component where no coating is desired	**Zero environmental impact** – no effluents or toxic chemicals

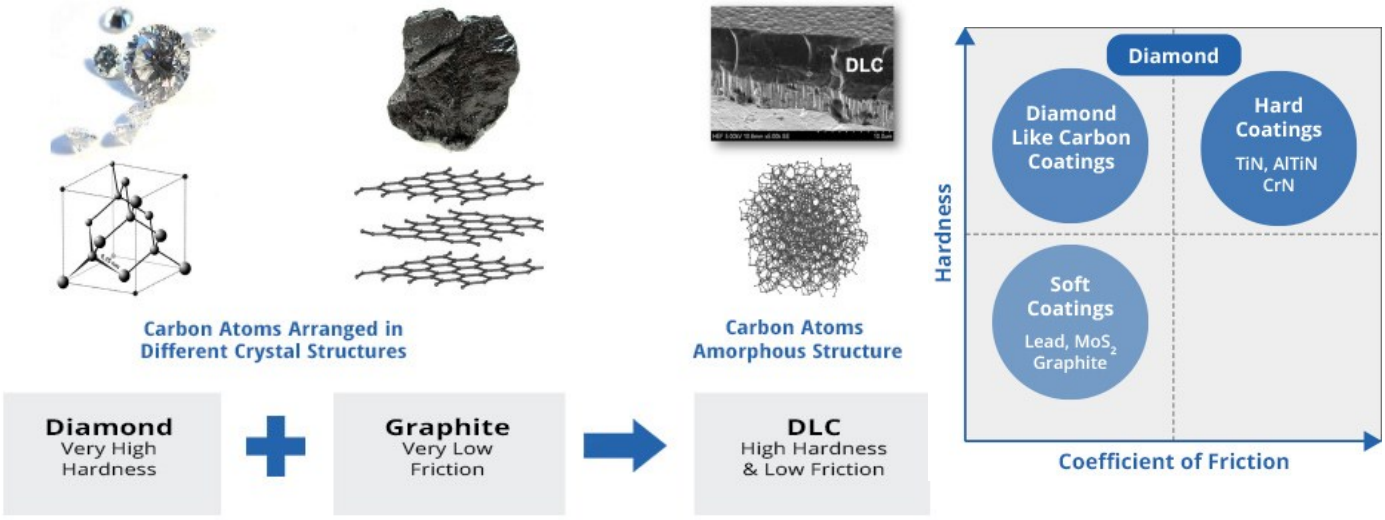
PVD Color Options

PVD Coatings can be offered in a diverse range of colors, depending upon the chemical composition of the coating. Some typical colors are **Gold** (Titanium Nitride); **Champagne/Light Gold** (Zirconium Nitride); **Silver** (Chromium Nitride); **Silver-Grey** (Titanium Carbo Nitride; **Black** (DLC); **Rose-Gold** and **Rainbow**. Firearm components can also be pre-blasted or pre-polished to provide different surface finishes, include matte, semi-matte and polished. PVD coatings can also be deposited on chrome plated components.

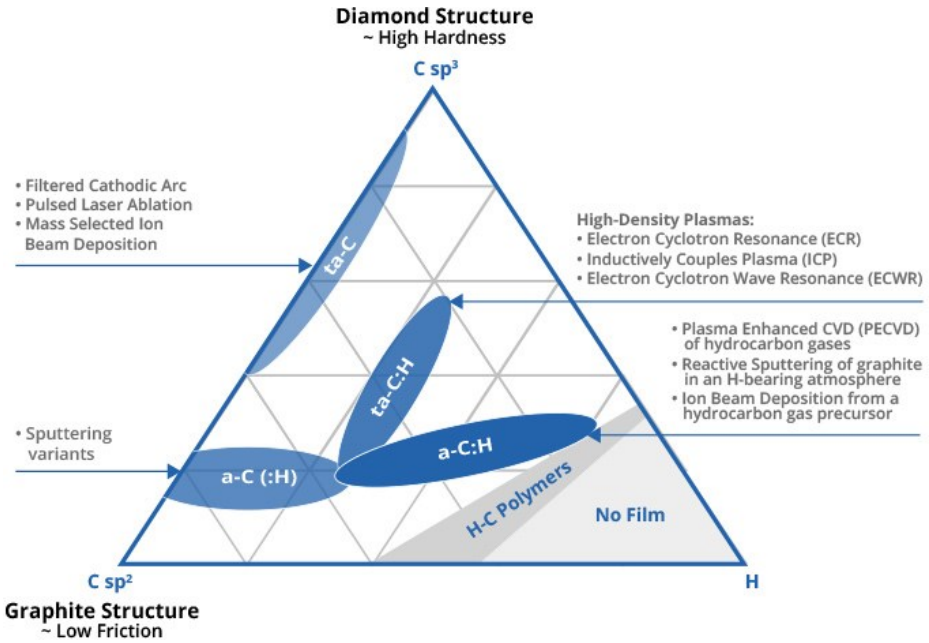
DLC Coatings Overview

In recent years, a new generation of PVD + PACVD (plasma-assisted CVD) coatings has gained widespread commercial success. As is well known, in nature carbon can exist in two allotropic forms. Carbon, in a **Diamond** crystal structure, is one of the hardest know materials. Carbon, in a **Graphite** crystal structure, is very soft and lubricous. Carbon-based coatings, referred to as **Diamond-like-Carbon (DLC) coatings**, combine these two different properties of diamond and graphite - hence possess high hardness levels - in the range of conventional tribological PVD coatings (1500 - 3200 HV), coupled with a coefficient of friction which is 200-500% lower than that of conventional PVD coatings. These DLC coatings are generally amorphous (without a regular crystal structure) in nature.

What is a Diamond-Like-Carbon (DLC) Coating?



DLC coatings can be deposited using a diverse range of technologies and alloyed with elements such as hydrogen and metals such as chromium. These constituent elements and deposition technique can have a significant impact on the properties and structure of the DLC coating.



DLC Coatings for Firearm Components

DLC Coating Features:

- Coating thickness~2 to 4 microns (0.0001”-0.0002”) - minimal change in dimensions of un-coated parts.
- Low temperature (<400°F) process - no distortion of parts during coating.
- Very high adhesion level of the coating to the steel surface.
- DLC coatings not change the properties of the base metal and is sometimes the preferred choice for stainless steels.

DLC Coating Advantages:

- Ultra-low friction between sliding components
- Prevents jamming of moving/sliding parts—ensuring reliable operation
- Reduces the need for frequent lubrication. Low or no-lubrication conditions minimize dirt/dust accumulation—reduced servicing requirements
- Reduced carbon fouling due to the ‘non-sticking’ nature of the DLC coating
- A very high hardness surface layer that significantly improves scuffing and overall wear resistance
- Appealing cosmetic finish
- DLC will mimic the surface finish present on the component. If you desire a matte finish, polished finish or something in between, your product can be finished accordingly prior to coating with the confidence that your targeted finish will be preserved in the coated product.

Surface Finishing Processes for Firearm Components

HEF, through its NCT facility in Kennebunk, Maine, offers a full line of CERTESS FiN surface finishing processes to improve your product's performance. Several surface finishing options are available to match the part geometry and surface finish requirements including REM®, Keramo®, media blasting and vibratory finishing. A variety of alloys can be processed including steel, stainless steel, aluminum and titanium.

REM® Finishing

When surfaces are in contact with each other surface roughness will increase the friction between the two parts which can result in increased wear, higher friction and energy loss or heat generation.

REM® isotropic finishing is a non-direction superfinishing process that combines the use of chemistry that is added to the bowl with the ceramic media to accelerate the removal of asperities or peaks on your part's surface and create low Ra surfaces. Machining and grinding create surfaces with defects and directional machining or grinding lines. The REM process will reduce the roughness of the surfaces created from machining or grinding and reduce the surface roughness producing low Ra surfaces.

During the refinement portion of the process, a chemical is added to the bowl to create a reaction with the surface on the parts being processed. The chemistry introduced does not create hydrogen embrittlement in parts and will react with the steel or non-ferrous alloy creating a soft conversion coating on the surface. As the parts rotate through the media in the vibratory bowl, the ceramic media wipes the soft conversion coating from the peaks allowing the chemistry to create a conversion coating on the unreacted surfaces below. This process contuse continually reduces the peak height and lowering the surface roughness. As the process continues and the peaks are removed preferentially each time the conversion coating is wiped from the surface and a new conversion coating forms on the exposed surface. This reduces the peak height and lowers the surface roughness. The process is designed to allow the valleys to remain on the surface and hold lubricants to further reduce friction. During the second stage of the process the burnishing chemistry is added to the bowl which neutralizes and works with the ceramic media to remove any remaining refinement chemistry and creates a mirror like finish.

Profile of typical ground or machined

Profile of the surface after initial refinement

Profile of the surface after further refinement

Keramo®

The **Keramo®** process is a non-directional process that uses a porcelain media to reduce peak height and polish the surface of parts. The Keramo® process is a mass finishing process that uses vibratory bowls to create a smooth low Ra surface. The process combines polishing with a porcelain media and a soap solution to scrub the surface of the parts reducing the surface roughness.

Phosphating for Firearm Components

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

HEF, through its **CALICO location in Denver, North Carolina, offers Phosphating treatments** for Firearms. This treatment is a cost-effective option for firearm applications where the primary aim is to have good run-in behavior, reduce mild nicks/scratches and somewhat improved corrosion resistance compared to bare surfaces. The surface hardness from Phosphating is lower than that obtained from Liquid Nitriding and significantly lower than from DLC coatings. Hence for applications where the firearm will encounter erosive wear, excessive scuffing, lubricant deprived operation and prolonged outdoor usage, Phosphating may not be an effective solution.

Electroless Nickel Plating for Firearm Components

Electroless Nickel Platings are used in the Firearms industry when a metallic looking finish is required. These platings can be applied to complex shaped firearm components and provide good level of wear and corrosion protection. HEF, through its **Tech Nickel location in Benton Harbor, Michigan, offers Electroless Nickel Platings** for Firearms.

Surface Treatment and Coating Selection for Firearm components

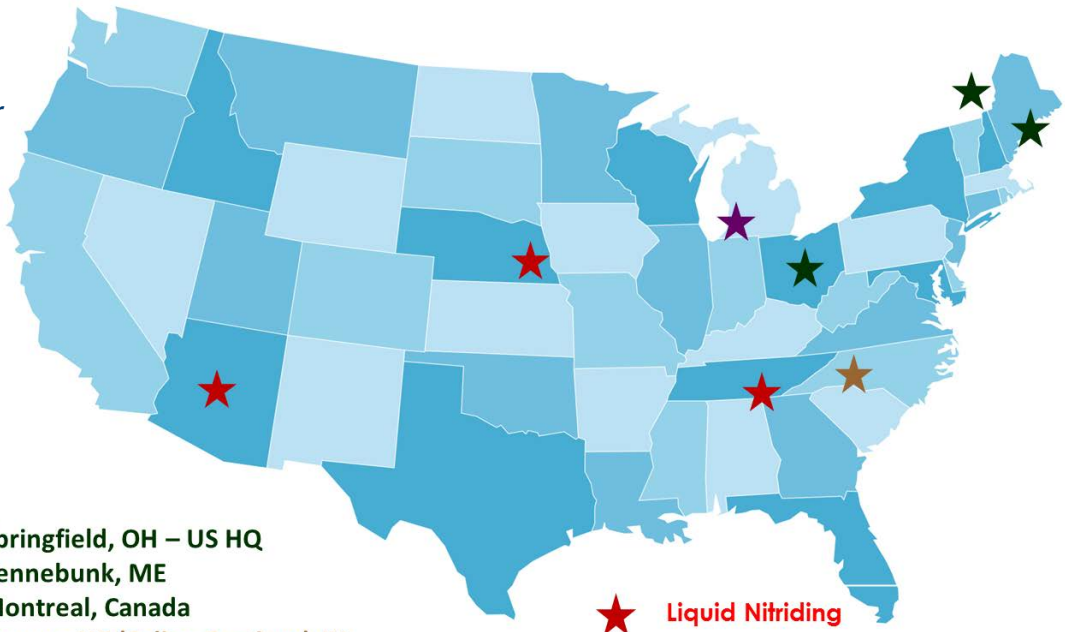
Surface treatment and coating selection for firearm components depends upon several factors, such as:

- **Service conditions:** DLC and Melonite QPQ parts are used every day in demanding environments. These surface treatments have been tested in the most demanding environments and are used by military personnel daily providing consistent reliable performance regardless of the environment. Components that would normally see corrosion and wear from being exposed to sever environments can now see extended service life by using our advanced surface treatments.
- **Performance considerations:** Our CERTESS Carbon DLC coating provides a low friction surface whether it is dry or lubricated condition. In environments where light or no oil is desired, DLC will continue to provide a low friction surface for firearm components. Moving components that experience friction during use are candidates for our CERTESS Carbon DLC coating. The DLC coating provides a hard, wear resistant surface to prolong the life or moving components. Our Melonite QPQ process is non-directional and will provide a uniform layer on ID surfaces as well as OD surfaces. The nitrided case improves erosion resistance meeting or exceeding what is normally realized from a chrome plated barrel and it provides improved corrosion protection far better than phosphating or bluing.
- **Mechanical design and metallurgy of the component:** We work with design engineers to ensure parts are designed properly for the DLC or QPQ process. We review heat treatment, surface roughness and part design to ensure the integrity of the part is not compromised and we meet the targeted performance requirement for each design. Our CERTESS Carbon DLC is deposited at 450 °F only- providing design engineers with options for components that cannot withstand the 950-1075 °F process temperature of our QPQ process.
- **Economics:** HEF's coatings and surface treatment have diverse properties and price points that fulfill every need and budget. Liquid Nitriding treatments generally tend to be lower priced than DLC coatings. Pricing is a function of quantities treated per batch; part geometry complexity; thickness of the surface treatment/coating and surface finish requirements.
- **Cosmetics:** Both Liquid Nitriding (ARCOR® & MELONITE®) and CERTESS DLC coatings produce an attractive black color- which is very durable and does not tarnish or scuff with time and usage. Specific PVD coatings can be specified if colors such as Gold (Titanium Nitride); Champagne/Light Gold; Silver Silver-Grey, Rose-Gold and Rainbow are required.

US & CANADA JOBBING FACILITIES

HEF, through its various facilities in the US and Canada, offers a diverse range of treatments and coatings that provide performance enhancement solutions for the specific mechanical and operating conditions experienced by various components utilized in different kinds of firearms– including handguns, shotguns, semi-automatic rifles etc. In some cases, one firearm can have components with different surface treatments-depending upon performance and metallurgical factors.

Please consult your nearest HEF location for advice and recommendations regarding the best options for your firearms.



- ❑ Springfield, OH – US HQ
- ❑ Kennebunk, ME
- ❑ Montreal, Canada
- ❑ Denver, NC (Calico Coatings) JV
- ❑ Kearney, NE
- ❑ Chattanooga, TN
- ❑ Phoenix, AZ (TS WEST) JV
- ❑ Benton Harbor, MI (Tech Nickel)

★ Liquid Nitriding
★ Liquid Nitriding + PVD/DLC Coatings
★ PVD/DLC Coatings + Phosphating + PTFE/FEP Coatings
★ Liquid Nitriding + Nickel Plating

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