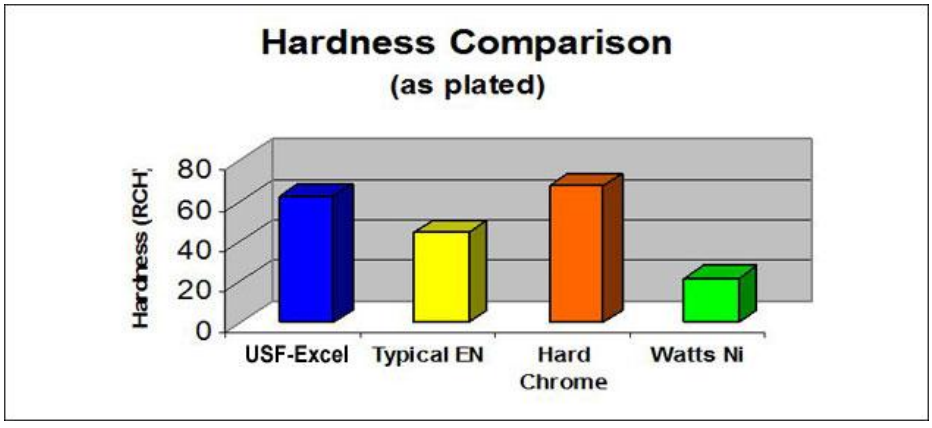
New "Rock" Hard Electroless Nickel Process:
A Review of Operation and Application Benefits

For years, engineers seeking durable coatings with hardness values above 60 Rockwell C scale had the option of either hard chrome or heat treated electroless nickel. Unfortunately, heat-treating EN to increase deposit hardness presents many problems. Deposit shrinkage and cracking often results in a dramatic reduction in corrosion protection. In addition to this, magnetic properties, stress and solderability are also adversely affected. Finally, if not heat-treated in a vacuum or inert atmosphere the deposit appearance becomes objectionable due to various colored oxides. When faced with all of these problems many engineers simply opted for the hard chrome.

In the early 1990's suppliers introduced low phosphorus electroless nickel that showed much promise. High-as-plated hardness and excellent corrosion resistance in alkaline environments were promoted and many considered it an excellent choice as a replacement for hard chrome. But low phosphorus chemistry never took off as a replacement to hard chrome for several reasons. The chemistry required to produce a low phosphorus deposit is more expensive than conventional EN. Not a good thing when competing with hard chrome. Also, the process is somewhat more difficult to operate. Loading, agitation, hypophosphite concentration and pH must be monitored closely to attain optimum performance and maintain the low phosphorus content.

Up to this point, a very hard EN deposit could only be produced through a deleterious heat treatment or a temperamental low phosphorus process. That is, until now. **USF-Excel** is United Surface Finishing's latest discovery in electroless nickel technology and was developed to overcome these problems.

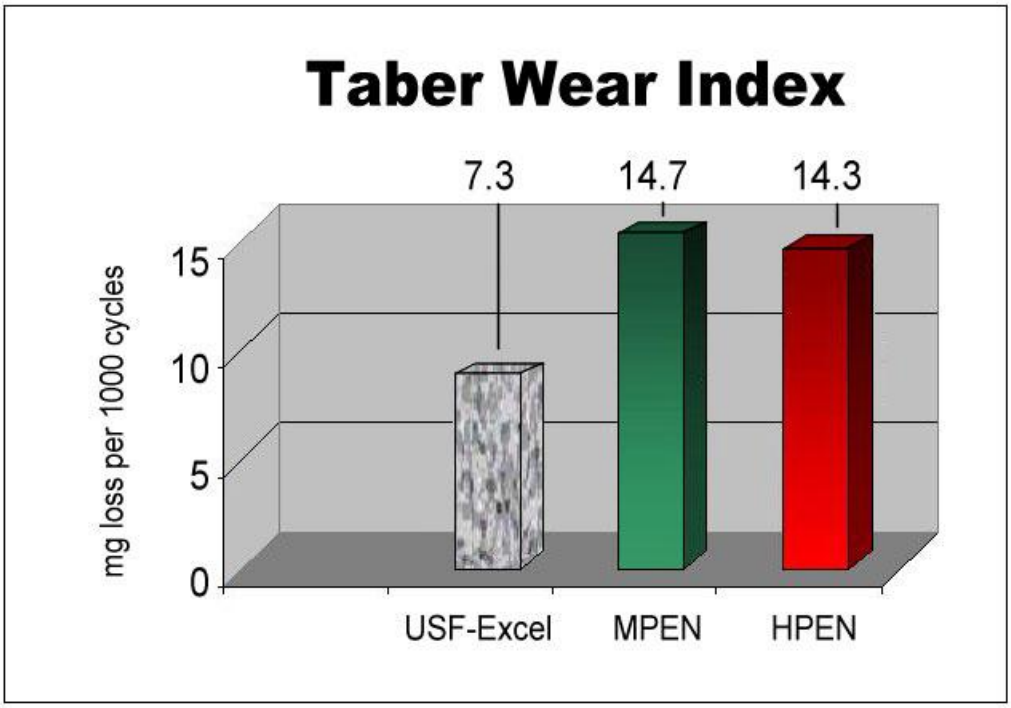
The **USF-Excel** Process yields a deposit with an as-plated-hardness of **63 Rockwell** C scale. That's an increase of nearly 40% over conventional electroless nickel deposits and pretty close to stress relieved hard chrome. Coating hardness of **USF-Excel** along with other deposits is presented for comparison below:



Often times heat-treating is not possible. Some substrates can't be subjected to these high temperatures due to impact on critical tolerances and/or effect on surface hardness of the components. In some cases heat-treating can be impossible due to size constraints and is often time consuming. In addition to this, heat treating increases the cost of the process. **USF-Excel** is an alternative.

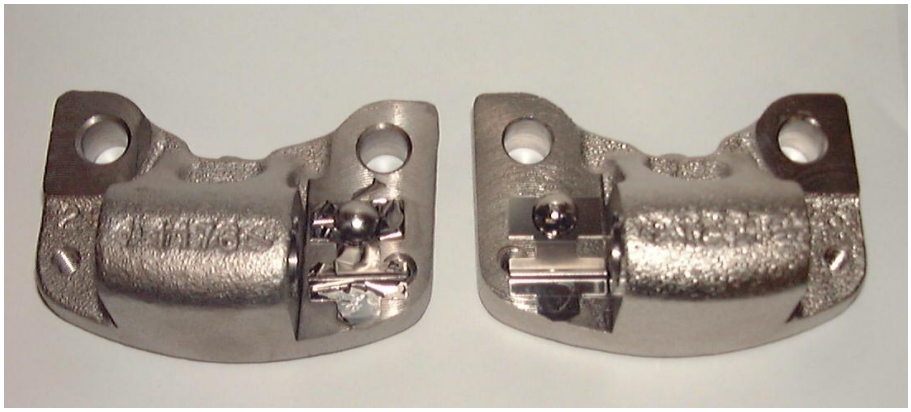
USF-Excel is an ideal engineering coating for today's demanding wear applications. The following graphs illustrate the increased wear resistance of this product when compared to conventional electroless nickel.

If the **USF-Excel** as-plated hardness is not enough, heat treatment can increase it further. Caution should be exercised when heat-treating **USF-Excel**. You will note maximum hardness of **USF-Excel** and concomitant wear resistance is attained at lower than expected temperatures and/or shorter heat treatment time. The graphs below indicate the **increased** wear of **USF-Excel** after a conventional 1-hour bake at 750° F. The maximum hardness of **USF-Excel** is 1000 VHN (68 RCH) and is attained by baking for **only 20 minutes** at a temperature of 750° F.



An additional benefit of the **USF-Excel** deposit is intrinsic deposit stress. Unlike most low to medium phosphorus deposits, **USF-Excel** exhibits compressive stress. This is important for a number of reasons. Past studies have found that many deposits exhibiting high tensile stress performed poorly in wear tests when compared to slightly softer, compressive stressed deposits. This clearly supports the claim that deposit hardness is not the sole-determining factor in wear performance of a coating.

Another benefit of compressive stress is adhesion. Pretreatment of difficult to plate substrates is less critical when applying a deposit of this type. The photos below illustrate this. The one on the left is a 0.5 mil deposit from a tensile stressed medium phosphorus EN process. The part on the right is plated in **USF-Excel** to the same thickness. Pretreatment for both was the same, yet the compressive stressed **USF-Excel** adhered to the 316 stainless steel tab.



In addition to the aforementioned advantages, compressive stress deposits like the **USF-Excel** will not reduce the fatigue strength of the plated component, thus ensuring its possible use in aerospace applications.

Design engineers take notice! Electroless nickel plating as you know it may never be the same. Well, maybe that's pushing it. But if you consider the elimination of heat-treating, excellent deposit properties and great performance you may find the hardest part of the process is definitely the deposit.