SURFACE FINISH GUIDELINES

FINDING THE OPTIMUM SURFACE FINISH

To achieve the optimum seal performance it is critical for the mating hardware surface finish to have defined characteristics that address the roughness, directional orientation or “lay” and hardness for reliable seal efficiency and life. As the Aerospace industry transitions from the traditional hard chrome plating toward the use of HVOF (High Velocity Oxygen Fuel) coatings, the definition of an optimum surface finish has also changed.

Until recently hard chrome plating had been effectively utilized for dynamic surfaces as the traditional coating method. To this end, Aerospace seal gland specifications have been published which include surface finish requirements that are proven to be complimentary to efficient seal performance, primarily when used with established elastomeric and PTFE contact seals.

It is important to recognize the distinct differences between hard chrome plating and HVOF coating. Most notable is the manner in which chrome and HVOF interact with seals and bearings in dynamic applications. Experience with chrome has shown that with increasing time in service, the chrome surface finish will “polish” and become smoother. Conversely, HVOF surfaces have been found to remain relatively constant regardless of the accumulation of dynamic cycles with seals and bearings. As a result, Greene, Tweed has established distinct recommendations for chrome and HVOF-coated surfaces.

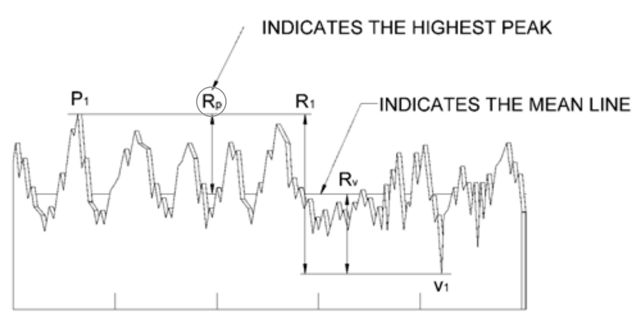
DEFINITION OF SURFACE FINISH PARAMETERS

Greene, Tweed’s recommendation for surface finish utilizes the definitions of the parameters as found in ISO 4287 for chrome plated or coated or finished HVOF.

Parameter	Definition of the Parameter ISO 4287: 1997
Ra	The arithmetic mean of a surface finish profile within a sampling length
Rp	The largest peak height of a surface finish profile within a sampling length measured from the mean line
Rz	The average of the sums of the largest valley depth to the highest peak of a surface finish profile within a sampling length
Rmr (Tp)	The ratio of the material length at a specified depth for a surface finish profile

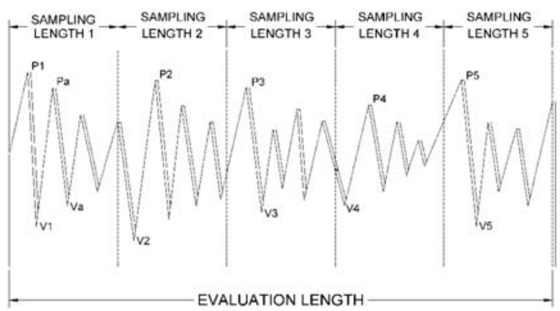
The information below references the Rp, Rz and Rmr surface parameters. This information is intended for reference only, and the specific ISO standard should be consulted for more detailed guidance.

Rp—This parameter is a measure of the largest peak and can be used to gauge the potential aggression of the surface. Considering HVOF surfaces are most generally comprised of tungsten and carbide particles, a low Rp is recommended to assure that no irregularly high peaks are present that could act to score or slice the seals and bearings.

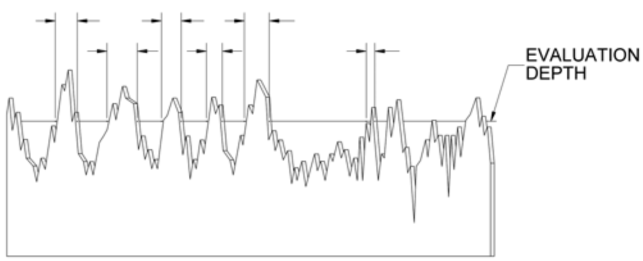


Rz—This is a measure of the average peak to valley height of the surface. Since boundary layer lubrication present on the surface can be beneficial to reduce the friction and corresponding wear on the seal, the Rz characteristic provides an indication of the surface’s potential to maintain the desired lubrication to the seal. While originally known as the “10 Point Height,” this characteristic has recently been re-defined by the ISO specification. Simply, it is now the average of the highest peak to the deepest valley of five sampling lengths taken across an evaluation length of a surface profile measurement.

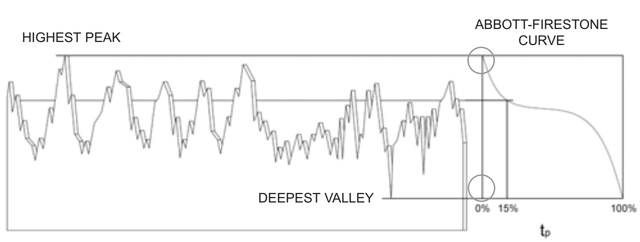
$$Rz\ (1997) = 1/5 \{\sum_{i=1}^{5} Z i\},$$
where $Zi = (P_i + V_i)$ for each sampling length



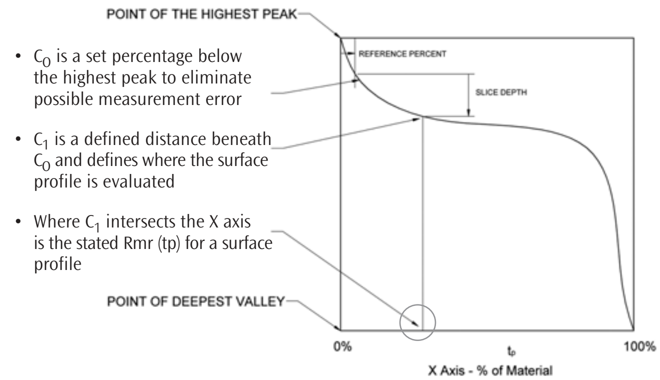
Rmr—This parameter provides information on the relative material ratio at a specific evaluation depth. In many applications this information is used to evaluate the load bearing capacity of the surface profile. Along with the other surface finish parameters, Greene, Tweed uses Rmr (tp) to determine the consistency of the surface profile.



Evaluation of Rmr (tp) is somewhat misunderstood. To clarify, the surface finish profile is evaluated by a generated Abbott-Firestone curve. This curve plots the percentage of material present in a surface profile based on the depth from the highest peak.



Using the Abbott-Firestone curve, the parameters C_0 and C_1 determine the evaluation depth for determining the Rmr (tp)



DYNAMIC CHROME SURFACE FINISH RECOMMENDATIONS

Elastomeric Contact Seals

Greene, Tweed's recommendation for elastomeric contact seals coincides with the specified surface finish definitions of the governing Aerospace specifications MIL-G-5514, AS4716 and AS4832.

Ra = 16 µinches (0.4 µmeters) Maximum

Note: In accordance with the previous revision of Aerospace Specification AS4716, Ra = 8 to 12 µinches (0.2 to 0.3 µmeters) is considered optimum for elastomeric contact seals.

This recommendation balances the two important aspects of desirable surface characteristics for elastomeric contact seals—the promotion of boundary layer lubrication between the seal and the hardware surface and minimal aggressive wear between the hardware and the elastomer seal material.

It is important to note that there has been some consideration in the Aerospace industry to expand upon the recommendations currently found in the Aerospace specifications by controlling other surface finish parameters beyond Ra. This is allowable with the additional parameters defined based on finishing and processing controls and historical performance data. Note, however, that consideration regarding the possible impact that the control of these additional parameters may have on other system production lead time. Economics should be balanced against the net benefit achieved by specifying parameters other than Ra. Acknowledging that the chrome surface finish is likely to polish/change after a short time in service, the long-term, net positive effect of controlling additional parameters for chrome, may be limited.

Reinforced PTFE Cap/Contact Seals

Due to the fact that PTFE materials are inherently self-lubricating, the need for boundary layer lubrication between the seal and the hardware is less critical than with elastomeric contact seals. As a result, hard chrome plating should be finished in such a manner as to reduce the boundary layer lubrication while still promoting a less aggressive surface finish topography. As a result, Greene, Tweed recommends:

Ra = 4 to 8 µinches (0.1 to 0.2 µmeters)

With the use of both elastomeric and PTFE contact seals it is important to obtain a "neutral" grain orientation to the machined surface. Many finishing techniques such as single point turning, grinding, honing, roller burnishing and polishing are used in the manufacturing process. A process that induces a directional orientation to the structure of the surface can negatively influence the leakage and wear behavior of the selected seal and should be avoided.

HARDNESS OF THE MATING SEALING SURFACE

A dynamic hardware surface hardness that is generally below 42 HRC will promote seal-induced polishing and wear to the mating metal surface and also inhibit the use of higher performance, wear-resistant-reinforced PTFE seal materials engineered for longer service life. Hardware surfaces with hardness greater than 42 HRC generally allow the selection of optimum seal materials for a balanced endurance life capacity.

HVOF APPLIED COATINGS, DYNAMIC SURFACE FINISH RECOMMENDATIONS

In conjunction with SAE as well as the industry sponsored HCAT (Hard Chrome Alternative Team), Greene, Tweed has developed an optimum dynamic surface finish profile recommendation for use with HVOF coatings. It is critical to note that HVOF behaves very differently than chrome because it does not polish over time and the coating has been shown to remain in its originally finished condition throughout its time in service. Additionally, since the most commonly recommended HVOF powders consist of both tungsten and carbide particles, both of which are known to be very dense and potentially aggressive to seals and bearings, it is critical that the proper surface finish be defined and verified for dynamic seal applications.

Greene, Tweed recommends the following surface finish for HVOF:

Ra = 4 µinches (0.1 µmeters) Maximum

Rp = 8 µinches (0.2 µmeters) Maximum

Rz = 40 µinches (1.0 µmeters) Maximum

Rmr = 70 to 95% at C0 = 5%, C1 = 0.25 Rz

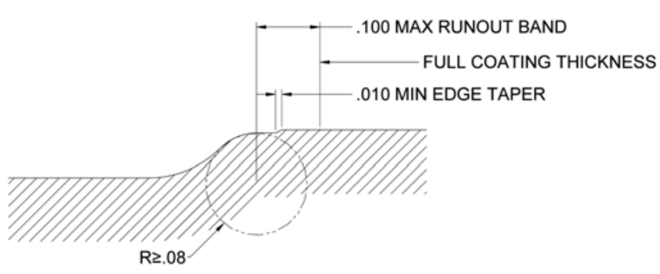
The definitions of the above characters have been explained previously and are determined by ISO 4287 and ISO 4288.

DYNAMIC COATING RUNOUT/LEAD-IN RECOMMENDATIONS

Experience has shown that the blending and runout of coating and plating also requires proper attention in order to minimize the possibility of seal installation difficulty or start-up efficiency concerns. Therefore, we recommend the following:

Chrome Runout

Chrome runout has been established to terminate on a geometric feature of the hardware, usually a radius or chamfer. While this approach has been used successfully in many aircraft system, it is critical that the runout band be smooth and free from pitting or raised inclusions. Pits or raised features in the runout band can be potentially aggressive to seals and bearings, causing axial scoring or tearing in the seal material. In the case of reinforced PTFE cap seals, scoring the seal material during installation is the leading cause of start-up wetting on new systems, with the wetting continuing until the system accumulates sufficient cycles under load to effectively break-in the scored sealing cap.



TYPICAL CHROME RUNOUT

surface finish \ product data

s u r f a c e   f i n i s h   \   p r o d u c t   d a t a

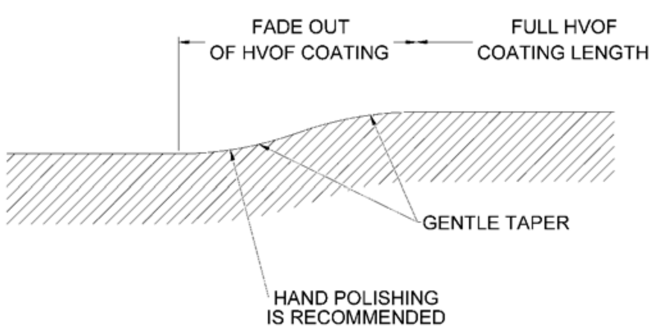
HVOF Runout

In order to promote the proper installation of seals on HVOF, it is recommended that care be taken with the proper specification and manufacture of the coating runout onto the parent material of the hardware. Since HVOF utilizes hard, dense particles such as tungsten and carbides, greater care in the preparation of the runout needs to be taken as compared to traditional chrome coatings.

While there is currently no established industry specification to guide the preparation of HVOF runout, some common criteria are emerging.

a) Long fade out is preferred—Traditional chrome runout has been specified as a finite distance from a chamfer or radius, with the typical runout less than 0.100 inch. For HVOF, much longer blending of the coating is preferred, with the amount of the blend to be determined by the manufacturing methodology and hardware geometry.

b) Hardware geometry—Traditional chrome runout was concurrent with a chamfer or radius in the hardware geometry. It is now recognized as beneficial, where possible, to incorporate a long taper in the parent material geometry to facilitate the runout and fade out of the coating. The HVOF coating can be feathered along the tapered geometry to create a more consistent, benign runout. The termination of HVOF in advance of a chamfer or radius makes it more difficult to fade out the coating, therefore increasing the possibility of the runout being aggressive to seals during installation.



The best results have been achieved through open communication with coating and finishing organizations that will be utilized during production. Conversations should be held at the time of hardware design in order to clearly communicate the criticality of the runout in terms of consistency and smoothness. These organizations have specific experience with masking, coating and finishing to provide specific recommendations in line with production capability.

Greene, Tweed believes in partnering with customers to design the best solution for each application. Our product test lab is available to assess surface finish recommendations as necessary. By working side by side with customers, we are able to design a solution, recommend a surface finish or develop a high-performance component to meet your unique needs. For further information on optimal HVOF surface parameters and their impact on dynamic seals, contact GT engineering.

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