

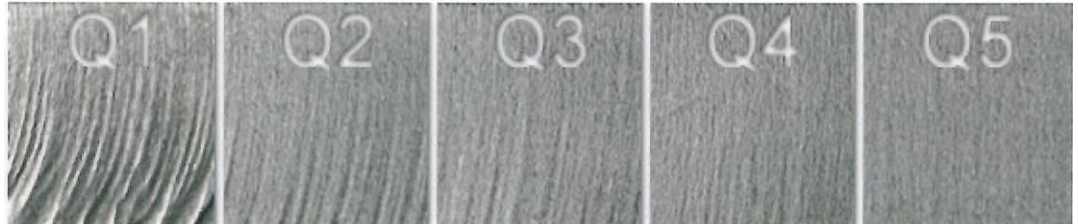
Vacuum System Surface Finishes

By
Ken Harrison, President

When building vacuum chambers, valves and other vacuum components, one of the questions that we always ask is, “What is the surface finish?” There are many possible options for material surface treatment, and the right finish can have a significant impact on the cost, appearance and functionality of the end product. In this article, I will describe the types of finishes that are available.

The first consideration is the edge surface condition, which is determined by how the material is cut. Some of the possible cutting methods are:

1. Oxy acetylene cutting
2. Plasma cutting
3. Laser cutting
4. Waterjet cutting
5. Abrasive cutting
6. Saw cutting
7. Machined edges
8. Ground edges



Waterjet Edge Quality Designations

I have listed these in the approximate order from the roughest and least visually appealing finish to the most precise and costly processes. The type of cutting process selected is a trade-off between aesthetics, tolerances and price. A common finish for us is waterjet cutting. For many applications, this is acceptable without further processing. The slower the cut, the better the finish that can be achieved with waterjet cutting. The edge quality can be specified by Q numbers as the above picture demonstrates.

In addition to the edge surfaces, the flat plate surfaces can vary greatly. Some of the options are as follows:

1. Number 0 finish is hot rolled annealed (also known as HRA or a mill-scale finish).
2. Number 1 finish is hot rolled, pickled and passivated.
3. Number 2D finish is cold rolled, annealed, pickled and passivated.
4. Number 2B finish, this is 2D plus a cold rolled bright finish between polished rollers. The finish is smooth and highly reflective. This finish is available only on material that is less than 1/4 inch thick.
5. Number 2BA is bright annealed finish, nearly a mirror like finish.
6. Number 3 grained finish is plate that has been sanded in a uniform direction with 80-100 grit.
7. Number 4 grained finish is plate that has been sanded in a uniform direction with 150 grit. It is not highly reflective, but a good general finish for vacuum components.
8. Number 6 finish is plate sanded with a rotating abrasive cloth. “Satin Blend” is an example and the finish is non-directional.
9. Number 7 finish is buffed and highly reflective, but it has some fine buffing scratches.
10. Number 8 finish is a true blemish-free mirror finish.
11. Bead blast finish is plate that has had the scale and imperfections removed by grit blasting. It is a common and inexpensive way to obtain a uniform finish.



Bead Blasted Vacuum Chamber

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12. Blanchard ground finish is used to make the material flat. It will have swirled grinding marks in a uniform pattern.
13. Machined all over is a finish that is produced by machining operations such as milling and turning. The pattern of the machining marks is determined by the type of machining process and also the types of cutters that are used. Generally this is a uniform, attractive finish, but not highly reflective. The roughness of the finish can be specified by an Ra number which is the arithmetic average of the peaks and valleys of the surface. One Ra equates to one millionth of an inch (for metric units the finish is called out in micro-meters which equates to 40 micro-inches). The Ra designation has replaced the older callout of RMS (meaning root-mean-squared). A conversion between RMS and Ra values along with sanding grits is as follows:

Ra (μ inch)	RMS (μ inch)	Ra (μ meter)	RMS (μ meter)	Grit Finish
4	4.5	0.10	0.11	Mirror
8	9.0	0.20	0.23	400
16	18	0.40	0.45	240
32	36	0.80	0.90	180
63	71	1.57	1.76	120
125	141	3.13	3.35	36
250	281	6.25	7.03	NA
500	560	12.5	14.00	NA
1000	1125	25.00	28.13	NA
2000	2250	50.00	56.25	NA

14. An electro-polished finish is a shiny finish that is obtained by electro-polishing. It will still show the marks of the other surface preparation. Electro-polishing commonly is done after fine grit blasting, #4 graining or on a 2B finish.
15. A lapped finish is a process to create a flat part with a finish of Ra 8 or better.

A summary of typical surface finishes by manufacturing methods is:

Process	Roughness Height Ra (μ inch)									
	2000	1000	500	250	125	63	32	16	8	4
Flame Cutting	-----XXXX-----									
Waterjet	-----XXXX-----									
Sawing	-----XXXXXX-----									
EDM	-----XXXXXXXXXXXX-----									
Milling	-----XXXXX-----									
Turning	-----XXXXX-----									
Laser	-----XXXXXXXXXXXX-----									
Grinding	-----XXXXXXXXXXXXXXXXXXXXXXXX-----									
#4 Grained	-----XXX-----									
Electro-Polish	-----XXXXXXXX-----									
Lapping	-----XXXXXXXXXXXXXXXX-----									