

Cosmetic Surface Quality — U.S. Military Specifications

Cosmetic surface quality describes the level of defects that can be visually noted on the surface of an optical component. Specifically, it defines state of polish, freedom from scratches and digs, and edge treatment of components. These factors are important, not only because they affect the appearance of the component, but also because they scatter light, which adversely affects performance. Scattering can be particularly important in laser applications because of the intensity of the incident illumination. Unwanted diffraction patterns caused by scratches can lead to degraded system performance, and scattering of high-energy laser radiation can cause component damage. Overspecifying cosmetic surface quality, on the other hand, can be costly. CVI Melles Griot components are tested at appropriate levels of cosmetic surface quality according to their intended application.

The most common and widely accepted convention for specifying surface quality is the U.S. Military Surface Quality Specification, MIL-PRF-13830B. The surface quality of all CVI Melles Griot optics is tested in accordance with this specification. In Europe, an alternative specification, the DIN (Deutsche Industrie Norm) specification, DIN 3140, Sheet 7, is used. CVI Melles Griot can also work to ISO-10110 requirements.

SPECIFICATION STANDARDS

As stated above, all optics in this catalog are referenced to MIL-PRF-13830B standards. These standards include scratches, digs, grayness, edge chips, and cemented interfaces. It is important to note that inspection of polished optical surfaces for scratches is accomplished by visual comparison to scratch standards. Thus, it is not the actual width of the scratch that is ascertained, but the appearance of the scratch as compared to these standards. A part is rejected if any scratches exceed the maximum size allowed. Digs, on the other hand, specified by actual defect size, can be measured quantitatively.

Because of the subjective nature of this examination, it is critical to use trained inspectors who operate under standardized conditions in order to achieve consistent results. CVI Melles Griot optics are compared by experienced quality assurance personnel using scratch and dig standards according to U.S. military drawing C7641866 Rev L. Additionally, our inspection areas are equipped with lighting that meets the specific requirements of MIL-PRF-13830B.

The scratch-and-dig designation for a component or assembly is specified by two numbers. The first defines allowable maximum scratch visibility, and the second refers to allowable maximum dig diameter, separated by a hyphen; for example,

- 80-50 represents a commonly acceptable cosmetic standard.
- 60-40 represents an acceptable standard for most low power scientific research applications.
- 40-20 represents an acceptable standard for low to moderate power laser or imaging applications that tolerate low light scatter.

20-10 represents a minimum standard for laser mirrors or extra-cavity optics used in moderate power laser and imaging applications.

10-5 represents a precise standard for very demanding high power laser applications.

SCRATCHES

A scratch is defined as any marking or tearing of a polished optical surface. The numeric designations for scratches are not related in any way to the width of a scratch, as the appearance of a scratch can depend upon the shape of the scratch, or how it scatters the light, as well as the component material and the presence of any coatings. Therefore, a scratch on the test optic that appears equivalent to the 80 standard scratch is not necessarily 8 μm wide.

The combined length of the largest scratches on each surface cannot exceed one-quarter of the diameter of the element. If maximum visibility scratches are present (e.g., several 60 scratches on a 60-40 lens), the sum of the products of the scratch numbers times the ratio of their length to the diameter of the element cannot exceed half the maximum scratch number. Even with some maximum visibility scratches present, MIL-PRF-13830B still allows many combinations of smaller scratch sizes and lengths on the polished surface.



Scratch-and-dig inspection

DIGS

A dig is a pit or small crater on the polished optical surface. Digs are defined by their diameters, which are the actual sizes of the digs in hundredths of a millimeter. The diameter of an irregularly shaped dig is $\frac{1}{2}(L + W)$, where L and W are, respectively, the length and width of the dig:

50 dig = 0.5 mm in diameter

40 dig = 0.4 mm in diameter

30 dig = 0.3 mm in diameter

20 dig = 0.2 mm in diameter

10 dig = 0.1 mm in diameter

The permissible number of maximum-size digs shall be one per each 20 mm of diameter (or fraction thereof) on any single surface. The sum of the diameters of all digs, as estimated by the inspector, shall not exceed twice the diameter of the maximum size specified per any 20-mm diameter. Digs less than $2.5 \mu\text{m}$ are ignored.

EDGE CHIPS

Lens edge chips are allowed only outside the clear aperture of the lens. The clear aperture is 90 percent of the lens diameter unless otherwise specified. Chips smaller than 0.5 mm are ignored, and those larger than 0.5 mm are ground so that there is no shine to the chip. The sum of the widths of chips larger than 0.5 mm cannot exceed 30 percent of the lens perimeter.

Prism edge chips outside the clear aperture are allowed. If the prism leg dimension is 25.4 mm or less, chips may extend inward 1.0 mm from the edge. If the leg dimension is larger than 25.4 mm, chips may extend inward 2.0 mm from the edge. Chips smaller than 0.5 mm are ignored, and those larger than 0.5 mm must be stoned or ground, leaving no shine to the chip. The sum of the widths of chips larger than 0.5 mm cannot exceed 30 percent of the length of the edge on which they occur.

CEMENTED INTERFACES

Because a cemented interface is considered a lens surface, specified surface quality standards apply. Edge separation at a cemented interface cannot extend into the element more than half the distance to the element clear aperture up to a maximum of 1.0 mm. The sum of edge separations deeper than 0.5 mm cannot exceed 10 percent of the element perimeter.

BEVELS

Although bevels are not specified in MIL-PRF-13830B, our standard shop practice specifies that element edges are beveled to a face width of 0.25 to 0.5 mm at an angle of $45^\circ \pm 15^\circ$. Edges meeting at angles of 135° or larger are not beveled.

COATING DEFECTS

Defects caused by an optical element coating, such as scratches, voids, pinholes, dust, or stains, are considered with the scratch-and-dig specification for that element. Coating defects are allowed if their size is within the stated scratch-and-dig tolerance. Coating defects are counted separately from substrate defects.



Clean-room assembly